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Machine
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Catechism

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MACHINE SHOP CATECHISM

MACHINE SHOP CATECHISM

CONSISTING OF

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PREFACE

The catechetical form of presenting information appeals strongly to the practical man who prefers a simple answer to a plain practical question rather than an exposition of the principles involved. This form has been employed in the columns of the *American Machinist* from time to time and a continuous flow of more or less elementary questions arising in the machine shop has led to this compilation. The answers are in accordance with common practice and are as complete as consistent with the form of presentation and the space restrictions imposed by the broad fields of work covered.

AMERICAN MACHINIST.

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MACHINE SHOP CATECHISM

CHAPTER I

MACHINE-SHOP CONSTRUCTION

1. *Q.*—What are the common types of machine-shop buildings?

A.—The multi-storied, built in a variety of styles and from a large number of materials, and the single-storied, having two prominent styles—saw-tooth roofed and the monitor roofed.

2. *Q.*—What is meant by the multi-storied type?

A.—That type where there are a number of floors arranged one above the other and connected by means of elevators and stairways. In large plants a familiar style has a long main building with projecting wings. Another is a series of parallel buildings with each floor level connected by passageways. Still another form is the gridiron style, in which the buildings surround a hollow square or series of interior courts.

3. *Q.*—What is meant by the saw-toothed roof construction?

A.—This is a type of roof peculiarly adapted to a one-storied shop. The roof consists of a series of bays, each roughly representing a saw-tooth with the point extending upward. These saw-teeth are set to run approximately east and west, and the more nearly vertical face of the saw-tooth is of glass and faces the north. The other leg of the saw-tooth is ordinary roof construction.

4. *Q.*—What is meant by monitor roof construction?

A.—A style used frequently for foundries, drop-forge shops and crane bays of machine shops. A lengthwise section of the roof including from one-third to one-half of its width is raised above the main roof in the form of a monitor, and the space between the two roofs is sided with glass.

5. *Q.*—What are the advantages of the multi-storied building?

A.—If land is expensive the multi-storied machine shop has the advantage of greater floor area for a given amount of ground area. For this reason it is a type more frequently used in the eastern part of the United States than in the western part. Because of the height the upper floors get better light and ventilation than is true of the average in a single-storied building. Further-more, the amount of travel for parts which must circulate from department to department is less in actual distance in a multi-storied building than in a single-storied building having the same amount of floor area and doing the same kind of work. For a given amount of floor space under cover the cost per square foot will run slightly less in a multi-storied building than in a single-storied building.

6. *Q.*—What are the advantages of the single-storied building?

A.—The absence of elevators and stairways permitting the free circulation of men and materials between departments. The single unobstructed view permitting the watching of all parts of the floor area from a single point of vantage. The uniformity of light obtained from the northward facing skylights; this latter point is considered one of the most important.

7. *Q.*—What are the common materials for machine-shop building?

A.—Up to about 10 years ago wood and brick were the common materials, with an occasional steel-framed building. Since 1903 a large number of concrete machine-shop buildings have been erected in the United States. The increase in the cost of lumber and the sentiment in favor of fire-resisting construction has practically eliminated wood, except for small and unimportant buildings. Concrete construction is growing in favor.

8. *Q.*—What is meant by mill construction?

A.—A type developed in New England for textile factories. It consists of brick pilasters carrying wooden floor beams with wooden interior posts and a heavy wooden floor. The floor beams are spaced usually 8 or 10 ft. on centers without intermediate joists. It is sometimes called slow-burning construction, as this is one of its important advantages.

9. *Q.*—How is the roof drainage cared for in saw-tooth construction?

A.—Some difficulty has been experienced in removing the stored water and melted snow from saw-toothed roofs. The present construction pitches each section of 40 or 50 ft. of the gutter between the saw-teeth to a central point, from which the drainage is taken down through the building in a downspout which frequently is inside an interior column.

10. *Q.*—What are the common types of machine-shop floors?

A.—The ordinary wooden floor, which is an overlay of maple, birch or beech flooring placed on a concrete or brick or tile arched underfloor, or a wooden underfloor on steel beams, concrete floors, and in a few cases brick-paved floors.

11. *Q.*—What are the advantages of concrete floors?

A.—Cheapness, particularly if they are a part of the superstructure of the building, rigidity, freedom from wear if properly constructed, and cleanliness.

12. *Q.*—What are the objections to concrete floors?

A.—The principal one that is alleged is hardness, which is supposed to bring about unpleasant physical conditions in the feet and legs of workmen. It is also alleged that machine parts and tools are damaged from being dropped on concrete floors where there would be no injury if dropped on a wooden floor. It is also alleged that dust arises from such floors, gets into the bearings of machines and produces wear. The real objection, however, is that concrete floors are cold. They tend to abstract heat from workmen's bodies and thus bring about conditions of discomfort. The action is the same as that of a shaded stone which feels gratefully cool when one sits upon it on a hot summer's day.

13. *Q.*—What methods have been used to heat concrete floors?

A.—Recognizing this last objection, a few factories have been constructed with heating pipes or ducts running through the concrete floors so that they can be warmed during winter and present no discomfort to the workmen.

14. *Q.*—How are machine tools fastened to concrete floors?

A.—Machines having box or inclosed bases, as milling machines, large planers, shapers, gear cutters, and the like, are leveled on wedges about 1/2 in. from the floor, and the intervening space run with a thick cement grout. The wedges are then slacked a little, settling the machine firmly into the grout. At the end of twenty-four hours the wedges may be removed and the machine used. Machines having feet are usually fastened against slipping by lag screws entering expansion sleeves fastened into holes drilled in the concrete. There is no difficulty in setting machine tools on concrete floors if the work is properly and carefully done.

15. *Q.*—How are fixtures fastened to concrete ceilings?

A.—Various methods have been used, all depending upon bolting some structure to the concrete ceiling and in turn fastening the fixtures to this structure. Both anchor bolts and anchor nuts are used, set in the concrete when it is poured. The Alford system used by the United Shoe Machinery Company extends a metallic T-slot crosswise of the machine-shop departments and spaced 10 ft. apart longitudinally. By inserting bolts into this slot fixtures can be clamped in position at any desired point. The slot itself is made of two angle irons placed with the vertical legs back to back, as shown in Fig. 1. This is used for the heavier fixtures, line shafting, countershafting, trolley rails and heavy piping. The lighter fixtures, such as supports for electric lights, small piping and the like, are held by a clamp passing around the bottom of the beam and fitting into grooves cast in its side (see Fig. 2).

16. *Q.*—What proportion of glass area is found in the side walls of modern machine-shop buildings?

A.—There has been a constant tendency to increase the amount of glass area to improve the interior natural light. In many cases the windows extend from floor to ceiling, with very small separating mullions and pilasters. A proportion of glass area of 75 per cent. or even somewhat greater is by no means unusual.

17. *Q.*—What proportion of glass area to floor area beneath is found in saw-tooth roofed buildings?

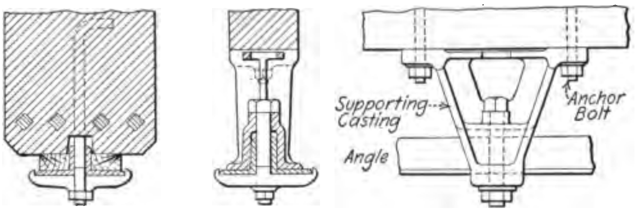


FIG. 1. T-SLOT SYSTEM FOR ATTACHING HEAVY FIXTURES TO CONCRETE CEILINGS.

A.—From 25 to 35 per cent., with an additional lighting area of from 50 to 65 per cent. on the side walls.

18. *Q.*—What are the common methods of artificial heating?

A.—By direct radiation, by indirect radiation, and by the circulation of hot water.

19. *Q.*—What is meant by direct radiation?

A.—In direct radiation steam either live or exhaust is circulated through pipes, pipe coils or cast-iron radiators, either with or without some vacuum system by means of which the air and condensed water are drawn out. This is the simplest method of shop heating and is used extensively especially in the smaller plants. No element of ventilation is connected with it.

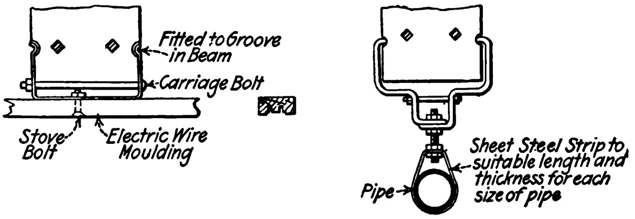


FIG. 2. DEVICE FOR ATTACHING LIGHT FIXTURES TO CONCRETE CEILINGS.

20. *Q.*—What is meant by an indirect heating system?

A.—This consists of steam or hot-water coils around which air is blown by fans, thus heated and thence blown into the machine-shop rooms. Air is usually taken from out-of-doors and is thus fresh and pure. This system combines the heating and ventilating for warm pure air is blown in and the vitiated air finds a natural outlet around the windows and other openings. It is extensively used in large shops.

21. *Q.*—What is a hot-water heating system?

A.—This consists of pipe coils and radiators through which hot water is circulated. The entering water is usually heated to a temperature of about 190 to 200 deg. F. and is expected to return at a temperature of about 150 to 160 deg. F. A common circulating pressure is about 30 lb. and a common factor is 1 sq. ft. of radiating surface for each 125 cu. ft. of room volume.

22. *Q.*—How are machine shops ventilated?

A.—In the smaller multi-storied shops, ventilation is usually obtained through the exterior windows, unless an indirect heating system is employed when warmed fresh air enters and drives out the vitiated air. In saw-toothed and monitor roof construction there are ventilating panes fixed in the roof sash through which foul air escapes. A carefully worked-out system has recently been installed in the Bosch Magneto Company's factory at Springfield, Mass. This consists of large fans arranged to circulate fresh outside air under ordinary weather conditions and fresh cooled air during the hot days of summer. The system combines fans for sucking out the vitiated air and discharging it, and another series of fans for introducing the fresh air. Through each room a system of partitions and louvers controls the circulation of this air so that each room is kept at a comfortable temperature and well supplied with pure air. It is a system invented and developed by a German engineer and transplanted to this country.

23. *Q.*—What systems are used for artificial lighting?

A.—Prior to the development of the newer high efficiency form of electric lamps, the common system was a combination of incandescents and arcs. The incandescent lamps were used for individual machine tools, bench spaces and the like and a limited number of arcs were used to give general illumination, especially of aisles and passageways. The introduction of the high efficiency lamp, tungsten, Nernst and Cooper-Hewitt has changed this method of lighting to one where general illumination is used to the exclusion of individual illumination. This does not mean the entire elimination of individual lights; on some operations they are still needed. But in general the modern machine-shop lighting is by means of high-power units each placed to cover a large area beneath.

24. *Q.*—What are common sizes and arrangement of tungsten lamps?

A.—Lamps from 100 to 250 watt rating are commonly used with a spacing of nine 100-watt or four 250-watt lamps to a bay 20 ft. square.

25. *Q.*—How is artificial lighting arranged in drawing-rooms?

A.—Indirect illumination is generally used. The lighting units are usually high-powered tungstens inclosed in inverted shades which throw the light against the ceiling from which it is reflected upon the drawing-board beneath. There have been installations of Cooper-Hewitt lamps but these are objected to because of the ghastly appearance that they give to persons' faces.

26. *Q.*—How is artificial lighting arranged in foundries?

A.—Modern foundry lighting uses medium-sized units, tungsten, flaming arc and Cooper-Hewitt lamps. The light from the latter is peculiarly penetrating and is therefore useful in places where there are shadows, dust, dirt and dark surfaces. An intensity on the work of three foot-candles is frequently specified. A foot-candle is the unit of illumination intensity, and may be defined as the intensity of the light normal to a surface 1 ft. away from a standard candle. If the surfaces and surroundings are very dark, an intensity somewhat greater than this may be necessary, but in general it is hardly probable that this factor need be exceeded.

27. *Q.*—What care should be given to lamps?

A.—The efficiency of electric lamps decreases very rapidly as the globes become covered with dust and dirt. For this reason they should be constantly kept clean. Well-organized factories arrange for a periodic washing of the globes, shades and reflectors of their electric lighting equipment.

28. *Q.*—How is drinking water supplied?

A.—Modern installations invariably make use of some form of bubbler foundation in providing drinking water in machine shops. The water itself is carefully analyzed to be sure that it is free from impurities of any kind and in the summertime it is frequently cooled by a refrigerating machine or by passing it through coils surrounded by ice. In well-organized plants the introduction of ice in the water itself is not allowed.

29. *Q.*—What arrangements are provided for storing street clothing?

A.—Lockers are universally being introduced in machine shops to-day to provide for street clothing. These are made in a wide variety of styles and sizes, a common size being 12 in. square and 5 ft. high in the clear. If space is cramped, double-deck lockers are frequently used. All lockers should be provided with a mesh door for purpose of ventilation and inspection. In some places a steam coil is run along the floor beneath the lockers to provide heat for drying out damp clothing. Each locker is provided with a lock, either in a master-keyed system or provided with a staple to receive a padlock to be furnished by the workmen.

30. *Q.*—What are some of the points that should be safeguarded in machine-shop construction?

A.—Among these are stairways, platforms, runways, passageways, ladders and elevators.

31. *Q.*—What should be done to safeguard passageways?

A.—All passageways and gangways should be kept smooth, in good repair, free from nails or other obstructions over which persons might stumble and fall and be adequately lighted at all times.

32. *Q.*—How should stairways be safeguarded?

A.—By being provided with permanent handrails, unless completely inclosed, and adequately lighted at all times.

33. *Q.*—How should platforms be safeguarded?

A.—Permanent elevated platforms in frequent use should be equipped with permanent stairways or stationary ladders. At points of danger they must be provided with a substantial guard rail, and toe boards to prevent parts from falling off.

34. *Q.*—How should ladders be safeguarded?

A.—All portable ladders should be provided with steel points or steel feet to prevent slipping.

35. *Q.*—How should elevators be safeguarded?

A.—All elevators except direct-acting plunger elevators should be equipped with an automatic device to catch the car in case it drops. Cars traveling at a speed of 250 ft. per minute or less should have a speed governor set to operate when the car's speed exceeds 50 per cent. of the normal speed. Cars with a speed higher than 250 ft. per minute should have the governor set to operate when the speed exceeds 30 per cent. of normal. All freight elevators should have gates of the self-closing type at each opening. Such gates except at the top landing should be not less than 5 1/2 ft. high with a bottom rail not more than 12 in. from the floor. If it is impossible to install a gate of this type, tell-tale chains may be fastened from the bottom of the car. All projections in elevator shafts such as floor beams, sills, bolts and the like, must be provided with smooth beveled guards unless the car inclosure is completely guarded.

36. *Q.*—How should the cars be covered.

A.—With a solid or wire-screened covering, the screen to be of not less than No. 10 wire, 1-in. mesh.

CHAPTER II

MACHINE-SHOP MANAGEMENT

37. *Q.*—What is shop management?

A.—Shop management is the term applied to the various systems, methods and means whereby the executives plan, organize and carry on the work of the shop. As practised to-day it is an art rather than a science; that is, its principles are based upon accepted practice rather than upon natural laws.

38. *Q.*—Is there a new element in the art of management which constitutes modern shop management?

A.—Yes, there is believed to be such a new element.

39. *Q.*—What is this new element?

A.—It is the mental attitude with which problems are approached. This attitude is one of investigation and research. It asks the reason for everything that bears on the problem to be investigated, attempts to discover the truth and reason for everything that is to be done and then acts upon the established facts. Properly applied, it is a scientific attitude of research applied to manufacturing problems.

40. *Q.*—What is scientific management?

A.—The term scientific management has been applied indiscriminately to various modern systems of management. It was first used by Frederick W. Taylor and his associates as a name for the development of the original Taylor system.

41. *Q.*—What are the regulative principles of modern shop management?

A.—Messrs. Alford and Church, *American Machinist*, Vol. 36, page 857, give these principles as: The systematic use of experience; the economic control of effort; the promotion of personal effectiveness.

42. *Q.*—How do these principles differ from former ones?

A.—The first principle is as old as human activity. From the earliest days man has always used his own experience, and that of others, in carrying on his work. The second principle is as old as manufacturing where large numbers of men were gathered together in one shop or place. It is the same as the principle of "division of labor" except that it adds the necessity of co-ordinating the labor after it has been divided. The third principle is comparatively new and points out the necessity of caring for the health and welfare of the employees. It not only takes in the physical surroundings which must be pleasant and comfortable if the workmen are to produce with their maximum effectiveness, but it also comprehends the atmosphere of the shop and the personal relations between members of executive force, members of the working force, and the relations between these two classes. It is the least understood and the least practised of the three principles, and at the same time promises more to industry than the others if followed with equal care.

43. *Q.*—Who should profit from an extension of the use of rational management?

A.—Employers, employees and the public alike must benefit directly if the possibilities of the extension of rational management are fulfilled. The employers should get greater product at less cost and be able to dispose of this at an increased profit. The employees should receive higher wages and work amid better surroundings. The public should be able to purchase manufactured articles at a lower price.

44. *Q.*—What are the important parts of a shop system under modern management?

A.—(a) The standardization of machines and tools; (b) time and motion study; (c) planning of the work; (d) routing of the work; (e) instruction of the workmen; (f) time-keeping; (g) method of wage payment; (h) determination of cost; (i) inspection of materials and product; (j) store-keeping; (k) safeguarding of workmen.

45. *Q.*—What is meant by standardization of machines and tools in a machine shop?

A.—On machines it means uniformity in the same parts for machines of the same size and kind, similar uniformity between machines of different sizes and kinds where practicable and uniformity in operating movements. Thus, if the lathes in a lathe department are standardized the centers, spindle noses, tool post slots, T-slots in the wings of the carriage and directions of motion for the tailstock spindle, carriage and cross slide are uniform. It further means that speeds and feeds are arranged in some uniform manner, preferably in a geometric progression with a constant ratio. The standardization of tools directly follows the standardization of machines.

46. *Q.*—Has this standardization been done to any extent?

A.—Standardization of machines has been done to only a limited extent, although its advantages are self-evident. The National Machine Tool Builders' Association has a special committee now at work on this problem. Lathe tools have been standardized by F. W. Taylor and William Sellers & Co., Inc.

47. *Q.*—What is time study?

A.—Time study is the art of observing, recording, analyzing and drawing conclusions from the times required to perform the elements of any operation. In the machine shop it is usually restricted to manual operations and machine operations. But it can be extended to mental operations as well.

48. *Q.*—What is motion study?

A.—Motion study is the art of observing, recording, analyzing and fixing the motions required to perform an operation. Its purpose is to find and fix a series of motions which will perform the operation with least expenditure of labor. It aims to cut out unnecessary and ill-directed movement of the body. It takes into account the physical and mental characteristics of the worker, the surroundings, equipment and tools that he uses and the variables that enter into the motions themselves.

49. *Q.*—What is meant by planning the work?

A.—The determining of all the operations, the feeds and speeds to be employed, the tools to be used and the kind and size of machine upon which a particular part is to be produced.

50. *Q.*—What is a planning department?

A.—A department which carries on time and motion study and plans the production of work as outlined above.

51. *Q.*—What is routing of work?

A.—Routing is determining the path and controlling the movements of all materials and products in the shop. It determines when raw material must be delivered to the shop to produce parts wanted at a certain future date. It sees that this material is delivered to the machine upon the first operation to be performed and then controls the movement of part from machine to machine until it is finally finished and delivered to the storeroom or erecting floor, and further controls the setting up of machines to meet shipping requirements. It makes sure that parts of machines will be finished in time to meet shipping promises. From the routing record the location of any piece in the shop can be determined at once. Further, the routing records form the basis of the permanent shop records and accounts.

52. *Q.*—Is the routing of work one of the important parts of shop management?

A.—Yes. It is one of the most important and in many shops considerable savings have been made by establishing routing without other parts of modern management.

53. *Q.*—How are instructions given to the workmen?

A.—In the most elaborate form the workman's instruction consists of a large sheet upon which each operation that he is to perform is listed, the tools to be used indicated, feeds and speeds given and the time for the operations stated. A less elaborate method gives an outline of the operations, their sequence, and states the tools to be used. In the first instance the speeds and feeds are given, usually by indicating the precise location of the speed and feed box handles, or giving the cone steps for the belts or the gearing to be used.

54. *Q.*—Are other instructions given besides those that are written?

A.—Yes, in the most elaborate form there are a number of foremen, known as functional foremen, who give instruction and information to the workmen.

55. *Q.*—What is meant by functional foremanship?

A.—Functional foremanship is a system whereby each foreman has charge of a certain function in handling the workmen instead of each one having full charge of a certain number of men and all the work that they produce. Under the Taylor system there are eight functional foremen as follows: Route clerk and order of work clerk, instruction card clerk, time and cost clerk, disciplinarian, gang boss, speed boss, repair boss, inspector. Each man is intended to be a specialist in the work that he is to perform. The idea is that the specialist in each one of these lines can accomplish more than the individual foreman who must do a certain part of all of these various kinds of work during each shop day. This is often referred to as a further extension of the principle of "division of labor."

56. *Q.*—What is a detailed instruction card like?

A.—Fig. 3 shows a detailed instruction card and tool list for a turret lathe operation. This is from an article by H. W. Reed, *American Machinist*, Vol. 36, page 915.

57. *Q.*—What are the common ways of keeping time?

A.—By time-clock or checking systems, in which the workman registers every entrance and exit from the shop; by time-cards or time-slips that are filled out by the workman himself and checked by his foreman; by using the telephone or some other mechanical device whereby the time is recorded at

DM 11 Symbol
INSTRUCTION CARD FOR OPERATION 1 *MV* 1.1/4 *VZ* 2 *B*.

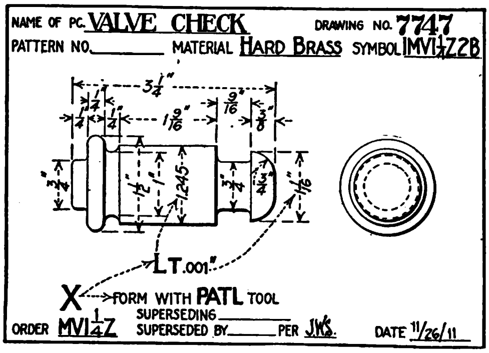
1 Sheets, Sheet No. 1		Drawing No. 7747	Machine No. L 26	Order No. *MV* 1.1/4 *V*
Material	Class No.	Pieces in lot	Time for lot	Bonus

Description of operation

TURN, CENTER, FORM AND CUT-OFF

Item	Detailed instructions	Feed	Speed	Element time per piece	Time for entire lot	Continuous on running time
1	Change time card				2.00	
2	Study instruction card and drawing				6.00	
3	Put 1 1/2 jaws in spindle				0.80	
4	Put stock in machine, adjust collets				0.80	
5	Set stop for stock in port No. 1				0.39	
6	Put turning head on turret in port No. 2				0.42	
7	Put in turning tool and set to turn to 1.245 diam.				6.00	
8	Set stop for turning tool				0.43	
9	Assemble *DSLP* No. 2—*CCC H* 3/8 and *D XS* in port No. 3				0.66	
10	Put *CC HD* in port No. 4				0.21	
11	Put *DSG U* No. 2 in front of cross-slide				2.10	
12	Put *P ATF* No. 667 in *DSG U* and clamp				0.75	
13	Set stop for *PATF* tool				1.10	
14	Put *PATL* tool in back of cross-slide and set				0.77	
15	Change speed and feed				0.40	
16						
17					22.83	
18	Turn turret			0.06		
19	Set stock to stop			0.15		
20	Turn turret			0.06		
21	Turn body of piece to 1.245 diam. 2 5/8 run	0.007 *A*	336 3*BF*	1.13		
22	Stop mach. gage and measure			0.36		
23	Turn turret and start machine			0.10		
24	Center end	*HF*	3*BF*	0.25		
25	Turn turret			0.06		
26	Set *CC HD* in center of piece			0.03		
27	Form with *PATF* tool	*HF*	3*BF*	2.10		
28	Move *PATL* tool to work			0.03		
29	Cut piece off	*HF*	3*BF*	0.37		
30	Put pc. in tote box			0.06		
31				4.76		
32	60 per cent. on handling time..0.91			0.55		
33	10 per cent. on machine time..3.85			0.39		
34				5.60		
35	Disassemble machine 4.00					
36	Time for lot = (No. pcs. × 5.60) + 4.00 + 22.83					
37						
38	Time for 50 pieces = 306.83 or 5.1 hours					
When machine cannot be run as ordered machine boss must at once report to man who signed this card.		6 Month	8 Day	10 Year	Signed R. Checked H.	

TURRET LATHE INSTRUCTION CARD FOR PIECE SHOWN


NAME OF PC. VALVE CHECK DRAWING NO. 7747
PATTERN NO.______ MATERIAL HARD BRASS SYMBOL IMVI$\frac{1}{4}$Z2B

X → FORM WITH PATL TOOL
ORDER MVI$\frac{1}{4}$Z SUPERSEDING______ SUPERSEDED BY______ PER J.W.S. DATE 11/26/11

DRAWING OF PART CORRESPONDING TO INSTRUCTION CARD

Form DM 17
TOOL LIST

Operation Symbol
1*MV* 1.1/4 *VZ2B.*

For Machine No. L 26. Draw. Nos. 7747.

Tools called for on this tool list must be issued in a tote box. The list should be placed in the tag pocket on the box and accompany the tools to and from machine.

	Class	No.	Symbol	Size
	Drill chuck	1	*CCC H*	1/2
	Center	1	*CC HD*	L 16
	Form tool-holder	1	*DSG U*	No. 2
	Socket	1	*DSLP*	No. 2
	Center drill	1	*D XS*	No. 22
	Micrometer	1	*MCM*	1/2
	Turning tool	2	*PATE*	1/2
	Forming tool	1	*PATF*	No. 667
	Cutoff tool	2	*PATL*	1/2
	Wrench	1	*WF H H*	1/2

Checks Req'd	Man's No.	Hour	Month	Day		Signed
[redacted]	[redacted]	[redacted]	6	8	1911	R.

When the tool list is not correct the gang boss must at once report the error to the man who signed this list.

CORRESPONDING TOOL LIST

FIG. 3. DETAIL DRAWING, INSTRUCTION CARD AND TOOL LIST.

a central station without any act on the part of the workman. The older method of having a time boy check each man twice a day has been generally superseded.

58. *Q.*—Are there any marked advantages in any one of these methods over the others?

A.—The system of using the telephone or some other mechanical device is growing in favor as it relieves the workman of clerical work and gives records with a great degree of accuracy, an important advantage in computing accurate labor costs.

59. *Q.*—What are the common methods of wage payment?

A.—The many wage payment systems can be grouped under four heads, daywork, piecework, premium or bonus work and gain or profit sharing. C. B. Auel, *American Machinist,* Vol. 36, page 945, gives the following detailed analysis.

Daywork	Piecework	Premium or Bonus Work	Gain or Profit-sharing
A. Hour	*A.* Straight	*A.* Halsey	*A.* Towne
B. Day	*B.* Manchester	*B.* Weir	*B.* Miscellaneous
C. Shift	*C.* Taylor Differential	*C.* MacLane Double Rate	
	D. Group	*D.* Rowan	
		E. Cardullo Diminishing	
		F. Gantt	
		G. Emerson	
		H. Santa Fé	
		I. Group	

60. *Q.*—What is meant by daywork?

A.—The method of wage payment wherein a certain wage is paid for a certain length of time worked. The agreed price may be so much per hour, so much per day or so much per shift. This is the oldest form of wage payment and is the one under which the greater part of both skilled and unskilled labor in the civilized world now operates and does not take into account the amount of work produced in any unit of time.

61. *Q.*—What is straight piecework?

A.—A method where payment depends upon the number of pieces produced and not upon the time employed. The rate may be a fixed price per piece, per hundred pieces, per gross, per thousand pieces or some other number. It is the second oldest wage payment system. Under this system the employer who is endeavoring to reduce cost has the constant incentive to cut the price. Thus this system, to a certain extent, is in disrepute.

62. *Q.*—What is Manchester piecework?

A.—The method that guarantees a day's wage in connection with piecework is known as the Manchester system.

63. *Q.*—What is differential piecework?

A.—The differential piecework system, devised by F. W. Taylor, establishes graded prices for a single job. A maximum price per piece is paid for the work if it is done within a certain minimum time. A low price is paid if this time limit is exceeded. There may be further classifications, but these are the more important.

64. *Q.*—What is group piecework?

A.—This resembles the old-fashioned contract system. A group of workmen are given a certain price for a job, upon which all are employed. The total earnings may be divided in any one of a number of ways; for instance, on the basis of their hourly or day rate and the number of hours or days worked by each. In a modification of this the job is given to a leading hand who receives the difference between the earnings at the piece rate and the wages paid to his helpers according to their day rates.

65. *Q.*—What is the Halsey premium system?

A.—This is the original of the many premium systems now in use, and was devised by F. A. Halsey. A time is estimated and fixed for the performance of each job. If the time taken by the workman equals this fixed time he receives the determined piece rate. If he is able to perform the work in a less time, he is paid a premium for a certain part of the time saved. In this simplest application this premium time is one-half of the saved time, although in some cases it has been fixed at one-fourth or one-third of the saved time. The day's wages are usually guaranteed.

66. *Q.*—What is the Rowan premium system?

A.—This is a modification made by James Rowan, of Glasgow, Scotland. The premium time is figured on the actual time in the proportion of the time saved to the time allowed.

67. *Q.*—What is the MacLane double-rate premium system?

A.—This gives every workman when hired two day rates. He starts at the lower one and continues at that rate until any month's pay shows an average of standard time to have been made on all jobs for that period. The higher day rate is then awarded and continued as long as the standard time continues to be made on every job during each month.

68. *Q.*—What is the Cardullo diminishing premium system?

A.—This system is similar to the Rowan except that a multiplier which is some fraction less than 1 is used when computing the premium time.

69. *Q.*—What is the Gantt bonus system?

A.—This system which was devised by H. L. Gantt gives each workman who is successful in doing all of his work within the time limit set a substantial bonus. If he fails to meet the time limit, he is paid a day rate wage. Further, the foreman receive a bonus for each workman who earns a bonus.

Still further the foreman receives an additional bonus if all of the workmen under him earn bonuses.

70. *Q.*—What is the Emerson efficiency system?

A.—This is a bonus system devised by Harrington Emerson. In its original form, if the workman equalled or bettered the standard time, he was paid at his hourly rate for standard time plus one-fifth.

71. *Q.*—What are gain or profit-sharing systems?

A.—There are a number of these in use in factories in this country whereby a part of the profits is returned as bonuses, the rate to each workman usually bearing some relation to the wages earned during the preceding year, or a number of years, and the length of service.

72. *Q.*—What items enter shop costs?

A.—The material cost, direct labor cost, and shop expense.

73. *Q.*—How is the labor cost determined?

A.—By finding the amount paid in wages, in directly producing the part or machines of which the cost is desired. It is customary to issue an order number for each machine or each part, and charge all direct labor to that number. By totaling the amount of wages, corresponding with the labor spent on that number, the direct labor cost is obtained.

74. *Q.*—How is the material cost found?

A.—In a manner similar to the one described above. All material used for a given part or machine is charged to the proper order number, and the totals found.

75. *Q.*—How is the shop expense found?

A.—By adding together all of the indirect labor costs, and indirect material costs, for the entire shop. This takes in interest, rent, taxes, insurance, salaries of the managers and executive, and all of the non-producing help in the shop. It takes in all of the general supplies and tools except such as may be charged directly to production orders. The total sum is distributed or proportioned over all of the product.

76. *Q.*—How is this expense proportioned?

A.—There are a number of methods. The simplest is to charge a certain rate against each hour of productive labor. This percentage may range from 100 to 150 per cent. in general machinery building. Another method is to apportion a percentage against each dollar spent for productive labor. A third and more just method of distribution is by the machine rate method. Here, each machine in the shop has a fixed rate. For every hour that that machine operates, this rate is charged against it as expense.

77. *Q.*—What further items enter into the total cost of machines and their parts?

A.—The fourth item is the selling expense, which must be added to the shop cost in addition to the profit before the selling price is obtained.

78. *Q.*—What is a cost system?

A.—A cost system is a method, records, etc., by means of which the cost of individual parts and machines is obtained. An accurate cost system is one of the most important parts of any shop management.

79. *Q.*—Is a cost system intended merely to record costs?

A.—No. A properly operated system will check the cost of parts as they are produced, will find if the costs are running high, and furnish information from which these costs can be cut down before a large number of pieces have been made.

80. *Q*—How are shop stores usually divided?

A.—Into three sections, raw material, finished parts, and tools and supplies.

81. *Q.*—How are raw materials usually stored?

A.—Castings and forgings are stored in bins, and bar stock either in horizontal or vertical racks. Very large castings are usually stored singly or stacked.

82. *Q.*—How are finished parts stored?

A.—Usually in bins and racks, which, in newer installations, are made of metal thus being fire resisting.

83. *Q.*—What is the two-bin method of storing parts?

A.—Two bins are provided for each part that is to be stored. A certain number of pieces are put into the first, and these are then used, as shipping orders are received. If any further lots come to the store-room, they are put in the second bin, and are left undisturbed until the first bin is empty. The purpose is to check automatically the number of pieces on hand as often as either bin is emptied.

84. *Q.*—What is a perpetual inventory?

A.—This is a record which gives at any time the number of pieces in store. All pieces received are added to the number on hand, and all pieces given out are subtracted. Thus there is always a balance showing how many pieces are on hand.

85. *Q.*—How are tools stored?

A.—Jigs, fixtures, and all kinds of small shop tools are usually kept in a distributing tool-room. Any workman can get a needed tool by depositing a check therefor. After he has finished using it, a return is made, and the check is given back.

86. *Q.*—How are machine parts inspected?

A.—There are two general methods, final inspection and operation inspection.

87. *Q.*—What is operation inspection?

A.—Every part is inspected after each operation. It is customary to send the parts to some central point called the Inspection Room.

88. *Q.*—What is final inspection?

A.—This is an inspection after the piece is completely finished. It is common to include final inspection with operation inspection where that is practised.

89. *Q.*—What is first piece inspection?

A.—This is an inspection of the first piece produced from every operation. After the machine is set up and the first piece made, this is taken to an inspector who must pass it before the job can be continued.

90. *Q.*—Who are traveling inspectors?

A.—Some shops have inspectors who are constantly walking about the machines inspecting an occasional piece as it is made. These men are called traveling inspectors.

91. *Q.*—How are tools inspected?

A.—In many of the best organized shops, all tools returned to the toolroom are carefully inspected before being put into the storage racks, if the cutting tools are dull, they are resharpened. If a part of a jig or fixture is broken or lost, it is replaced before the tool is stored. At all times all of the tools in storage are ready for immediate use. All of the fine measuring tools and gages are inspected on return in a similar manner.

92. *Q.*—How does modern shop management safeguard the workmen?

A.—By providing the best of surroundings; including ample natural and artificial light, fresh air, heat in cold weather, pure drinking water, means of escape in case of fire, emergency hospitals for accidental injury, and safeguards on machines and around permanent equipment.

93. *Q.*—What parts of machines should be guarded?

A.—Belts, pulleys, clutches, gears, flywheels, keys and keyseats, sprockets, setscrews, emery wheels and grindstones.

94. *Q.*—How should belts be guarded?

A.—All belts, ropes and chains, which are exposed to contact except those that are very small or moving very slowly, should be guarded so that there is no possibility of danger, particularly at the point where they run onto the pulley, sheave or sprocket. Further, all horizontal belts, ropes, or chains, 7 ft. or less from the floor, should be guarded where exposed to contact.

95. *Q.*—How should pulleys be guarded?

A.—All pulleys over 18 in. in diameter should be guarded where exposed to contact. All belt shifters on pulleys should be located within easy reach of the operator and so constructed that the belt cannot creep from the loose to the tight pulley. Further, all such shifters must have a lock to prevent accidental shifting. There must be a space on each side of a pulley sufficient to receive the belt, or the edges of the pulley must be protected by a hook or guard.

96. *Q.*—How should clutches be guarded?

A.—All clutches must be surrounded by a suitable guard to prevent danger, for practically all clutches have protruding parts, making them particularly dangerous.

97. *Q.*—How should emery wheels and grindstones be guarded?

A.—By a hood connected with an exhaust or water system to care for the dust. The hood must be of substantial construction to resist the shock of a bursting wheel and must fit closely around the wheel to retain all dust.

98. *Q.*—How should flywheels be guarded?

A.—All flywheels with spokes, running 6 ft. or less from the floor, must be guarded at points of contact. Flywheels in pits must be provided with a toe board around the opening.

99. *Q.*—How should friction drives be guarded?

A.—At the contact places where they are exposed. Such drives are dangerous because of the projecting parts.

100. *Q.*—How should gears be guarded?

A.—All gears exposed to contact should be entirely inclosed with a flanged guard, completely surrounding the teeth. Further, all gears having arms, spokes, or holes through the web over 18 in. in diameter, if exposed to contact, must be inclosed.

101. *Q.*—How should keys and keyseats be guarded?

A.—All projecting keys where exposed to contact should be cut off or surrounded by a guard and all keyseats in the ends of shafts, if exposed to contact, should be filled in, or surrounded by a guard.

102. *Q.*—How should setscrews be guarded?

A.—All projecting setscrews in moving parts, where exposed to contact, should be countersunk, protected by a solid collar or replaced by a headless screw. No setscrew should be allowed to project above the surface of the part which it enters.

103. *Q.*—How should wood jointers be guarded?

A.—By equipping them with safety cylinder heads and a guard placed over the knives to protect the operator's hands. Further, mats should be provided on the floor around all woodworking machinery to prevent the operator from slipping.

104. *Q.*—How should band saws be guarded?

A.—By inclosing both the upper and lower wheels and all of the saw blade except the part below the guide.

105. *Q.*—How should circular saws be guarded?

A.—By a suitable guide or cover over the saw which can be pushed out of the way by the piece being cut. Further, all ripping saws, other than self-feed saws, should have a splitter.

106. *Q.*—How should molders and machines with knife heads be guarded?

A.—All such knife heads, not automatically fed, must be provided with an inclosing guard. Such knife heads are some of the most dangerous parts of any machine, and, in fact, when used on any type of machine, if exposed to contact, they should be guarded.

CHAPTER III

DRAWING ROOM PRACTICE AND SYSTEM

107. *Q.*—How should a drawing pen be sharpened when dull?

A.—Separate the points slightly and rub the outside of the points on an oilstone holding the pen at an angle of 10 or 15 deg. With the stone, shape the end of the pen to a shape similar to a heart. Grind off the burrs on the inside and the pen is ready for use.

108. *Q.*—What is a protractor?

A.—An instrument for measuring angles.

109. *Q.*—For what purpose are "French curves" used?

A.—To draw curved lines of non-circular properties (see Fig. 4).

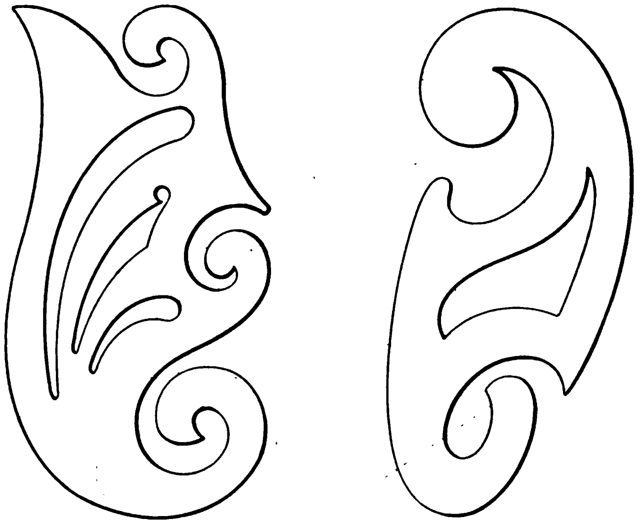


FIG. 4. "FRENCH CURVES."

110. *Q.*—Which side of the tracing cloth should be used?

A.—Either side is used, the dull being the preferable, owing to the fact that when placed in the file, dull side up, the cloth does not curl.

111. *Q.*—What is used to enable the ink to "bite" on the tracing cloth?

A.—Chalk, "pounce," pumice or talc.

112. *Q*.—What colors of ink are used for mechanical drawing?

A.—Black, sometimes red or blue for the center and dimension lines so they will appear rather dull on the blue print.

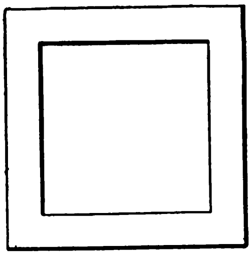


FIG. 5. EXAMPLE OF PROPER SHADING.

113. *Q*.—When making a tracing, which lines should be inked in first?

A.—Circles, arcs, and then straight lines.

114. *Q*.—What is good to use for removing dirt from a finished tracing?

A.—Gasoline, applied with a soft cloth, or "Artgum."

115. *Q*.—Should a draftsman move his T-square around the board?

A.—No; it should be placed at the left-hand side and lines at angles to its blade drawn by the use of triangles or a protractor.

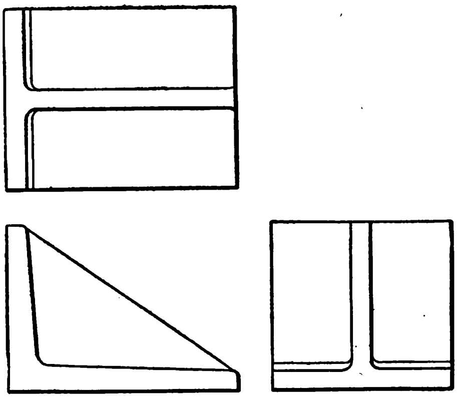


FIG. 6. EXAMPLE OF ANGLE OF DRAWING.

116. *Q*.—What are shade lines?

A.—Lines that are made heavier in order to indicate whether certain parts are hollows or projections, as shown in Fig. 5.

117. *Q*.—What general rule governs the drawing of shade lines?

A.—They are shaded as if a strong light were falling on the parts from the upper left-hand corner at an angle of 45 deg.

118. *Q.*—What is meant by scale?

A.—Scale is the ratio, for example, of the size shown on a drawing to the size of the actual part, as 3″ = 1 ft.

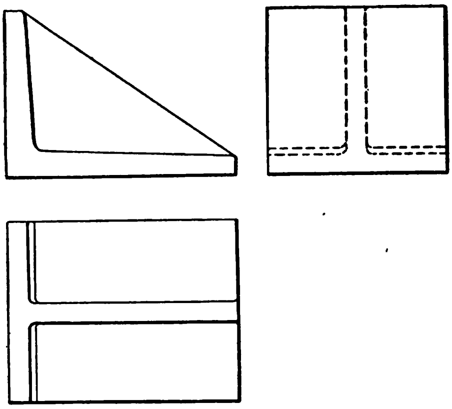


FIG. 7. VIEW IN FIRST ANGLE.

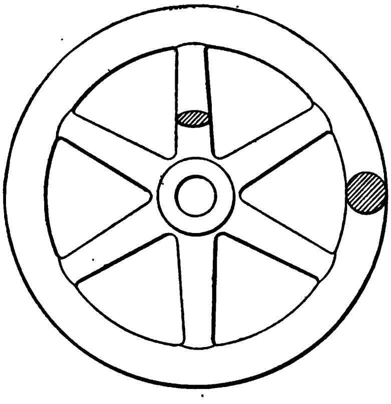


FIG. 8. EXAMPLE OF "TURNING UP" A SECTION.

119. *Q.*—To what scale should drawings be made?

A.—To the largest the sheet will hold; pattern and forging drawings usually full size.

120. *Q.*—How many forms of drawings are made?

A.—Pattern drawings }
Forging drawings } These are usually made full size.

Detail drawings: These are made with the necessary dimensions to enable the workman to make the piece.

Assembly drawings: These are usually made to a small scale and show the machine assembled with the necessary dimensions for assembling it.

121. *Q.*—What are working drawings?

A.—A drawing showing the form, size, material, finish and all the details of an object to be made.

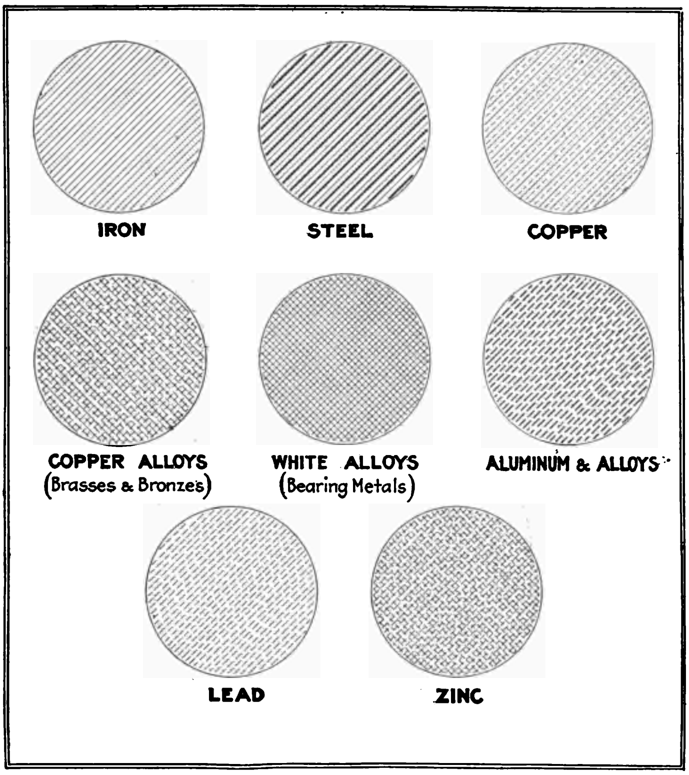

IRON
STEEL
COPPER
COPPER ALLOYS (Brasses & Bronzes)
WHITE ALLOYS (Bearing Metals)
ALUMINUM & ALLOYS
LEAD
ZINC

FIG. 9. CROSS-SECTIONS FOR METALS.

122. *Q.*—How should the lines be made for a drawing?

A.—The parts seen should be shown with a moderately thick even line. The unseen parts should be shown with a thin dotted line, center lines with a thin dot-and-dash line.

123. *Q.*—What is a bill of material?

A.—Specifications to enable the toolmaker or constructor to get what is necessary to make what is called for.

124. *Q.*—Where is it usually placed?

A.—Practice varies, but usually in upper right-hand corner of drawing.

125. *Q.*—How many views should be shown of a machine part?

A.—Enough so that no misunderstanding can arise in the mind of the maker of the part.

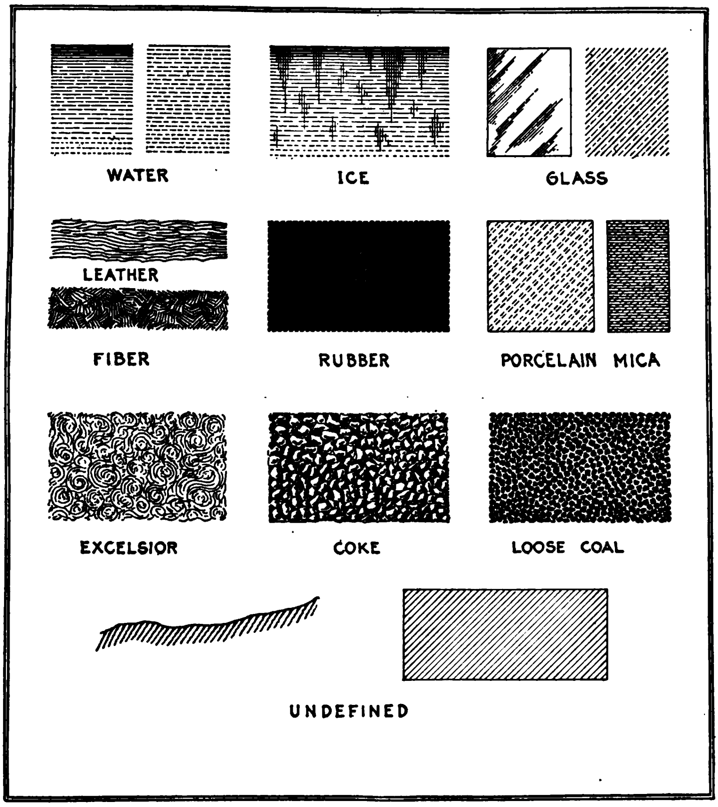


FIG. 10. SYMBOLS FOR MISCELLANEOUS MATERIALS.

126. *Q.*—What is meant by angle of a drawing?

A.—This is understood as the positions of the views as seen by the observer, shown in rotation to the vertical and horizontal planes, as shown in Fig. 6.

127. *Q.*—How is a view in first angle shown?

A.—As in Fig. 7.

128. *Q.*—What angle of drawing is used?

A.—In this country the third angle, on the Continent and England the first.

129. *Q.*—What is a cross-section, and when is it used?

A.—It is a section produced by passing a plane through a body. This is used for showing invisible interior parts, which otherwise could only be represented by dotted lines, possibly more or less confusing the outline work in the elevations or plans.

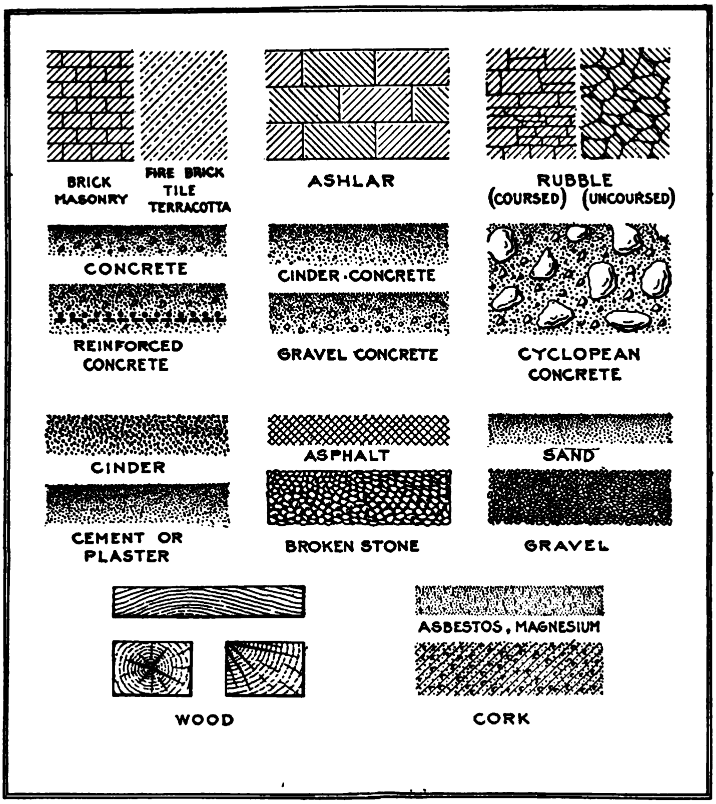


FIG. 11. SYMBOLS FOR BUILDING MATERIALS.

130. *Q.*—What is meant by "turning up" a section?

A.—Sometimes a second view may be avoided by drawing on the first view a partial view, as shown in Fig. 8.

131. *Q.*—What are the conventional sections used on drawings?

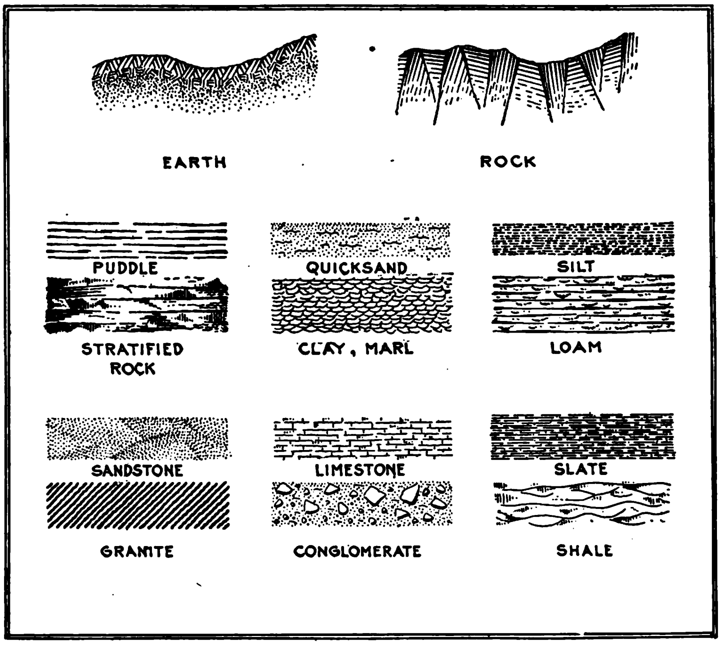


FIG. 12. SYMBOLS FOR GEOLOGIC FORMATIONS.

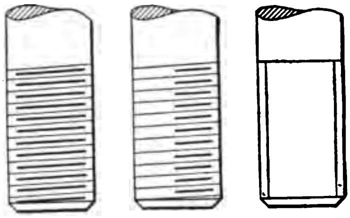


FIG. 13. USUAL METHODS OF SHOWING THREADS.

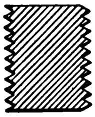


FIG. 14. THREAD SHOWN IN SECTIONAL PIECE.

A.—For various metals the *American Machinist* Standards are as shown in Figs. 9, 10, 11, 12.

132. *Q.*—What are the usual methods of showing threads?

A.—As shown in Fig. 13.

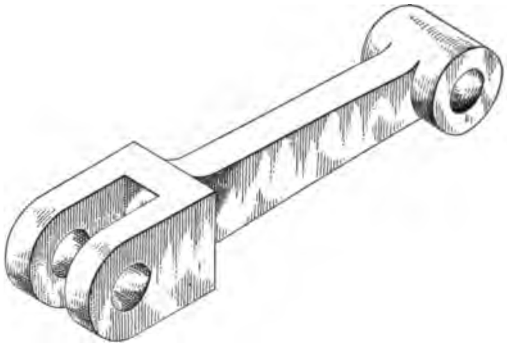


FIG. 15. EXAMPLE OF ISOMETRIC DRAWING.

133. *Q.*—How are they shown in a sectional piece?

A.—As shown in Fig. 14.

134. *Q.*—What is an isometric drawing?

A.—An example is shown in Fig. 15.

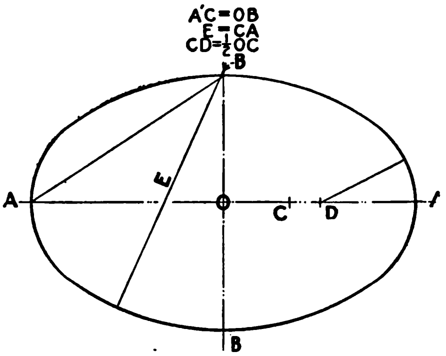


FIG. 16. HOW TO CONSTRUCT AN APPROXIMATE ELLIPSE.

135. *Q.*—What is an easy method of constructing an approximate ellipse?

A.—As graphically shown in Fig. 16.

136. *Q.*—What style of lettering should be used?

A.—Plain block letters of the slanting type should be used for notes, descriptive matter and dimension, and upright style for titles, captions and the like.

137. *Q.*—How should notes, etc., be printed on drawings?

A.—Use guide lines until practice enables them to be drawn neatly without such assistance.

138. *Q.*—What methods are used in placing titles on drawings?

A.—They are usually placed in the lower right-hand corner of the drawing. The title may be either written or printed on with a rubber stamp.

139. *Q.*—What abbreviations are commonly used on drawings?

A.—

F.A.O.	finished all over.
Rad.	radius.
Dia.	diameter.
R.H.	right hand.
L.H.	left hand.
P.TAP.	pipe tap.
CTRS.	centers.
C.I.	cast iron.
S.C.	steel casting.
Bz.	bronze.
C.R.S.	cold-rolled steel.
T.S.	tool steel.
O.H.S.	open hearth steel.
W.I.	wrought iron.

140. *Q.*—Are drawings always traced and blue printed?

A.—No. Tool drawings in particular are frequently inked on the original manila paper, shellaced to keep clean, and sent to the shop.

141. *Q.*—How are changes recorded on drawings?

A.—In various ways. Usually in colored ink.

142. *Q.*—How is the work of a drawing office divided?

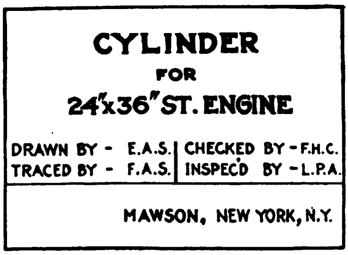
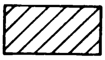
A.—Designing, detailing, tracing and checking.

143. *Q.*—How should drawings be filed?

A.—By symbols, which may be either size of drawing or kind of machine or both.

144. *Q.*—What is a fair sample of the main principles of drawing-room practice?

A.—As indicated by the following chart:

	Trimming size
Std. sizes plates...	9×12 12×18  CYLINDER FOR 24"x36" ST. ENGINE DRAWN BY - E.A.S. CHECKED BY - F.H.C. TRACED BY - F.A.S. INSPEC'D BY - L.P.A. MAWSON, NEW YORK, N.Y.
Drawings.........	18×24 24×36
Margins..........	All margins 1/2 in. wide.
Scales............	Use these scales in preference to others. 12 in. = 1 ft. full size 6 in. = 1 ft. half size 3 in. = 1 ft. quarter size 1 1/2 in. = 1 ft. eighth size Choose largest scale consistent with size of sheet.
Projection........	Use simple projections in third angle only. Make views to completely illustrate—no more—no less! Place views on sheet in same position as piece occupies in assembled machine. Work all views together. Do not try to finish one view before beginning another.
Dotted lines.......	Use few dotted lines. Only when absolutely necessary. Use cross-sections freely, in preference to dotted lines.
Pencil work.......	Make pencil drawing sharp and definite, absolutely complete, and check carefully before tracing.
Character of lines..	Lines for simple large scale details thus ———————— Lines for complicated small details thus – – – – – – – – – – Lines dotted thus ························ Lines center or axial: solid thus ———————— Lines center or axial: dash and dot thus —·—·—·—·— Lines dimension thus ←——— $4\frac{1}{8}''$ ———→ Lines cross-section 1/16 to 1/8 apart thus 
Figures...........	Make figures broad, bold and absolutely clear. Make all figs. read from lower or right-hand side of sheet.
Dimensions.......	Make all dimensions in inches up to and including 36 in. Inch marks (") are seldom necessary, except cases as 3′ 6″. Any dimension need occur but once on same drawing. Use enough dimensions to enable the piece to be made—no more—no less!
Notes............	Use notes freely to clear up doubtful points.
Thought..........	Always have in mind the workmen who are to use the drawing, the pattern maker, blacksmith and machinist. Always consider the machines available for the work.

SAMPLE OF DRAWING-ROOM PRACTICE.

CHAPTER IV

FACTORS IN MACHINE AND TOOL DESIGN

145. *Q.*—What great factors should be kept in mind in the designing of a machine?

A.—Simplicity, practicability, accessibility, strength and appearance.

146. *Q.*—Should appearance ever be sacrificed?

A.—Sometimes it is necessary, but if the machine is intended for the market, the appearance greatly assists the sale of it.

147. *Q.*—How should the weight be calculated?

A.—It should be sufficient for the needs and strength required, with a fair margin of safety, but should be so distributed as not to make the machine look cumbersome. Mere weight without regard to form is only in place in a scrap pile.

148. *Q.*—How may the weight of a machine often be reduced?

A.—By making the bed or column of ribbed or box form, and by substituting steel or wrought iron for cast iron in some of the parts.

149. *Q.*—In selecting materials for a given machine or tool part, what factors should be taken into consideration?

A.—Strength, resilience, stiffness, coefficient of friction, durability, cost of working into the required form, and cost of the material purchased on the open market.

150. *Q.*—Is it necessary to take all these into account when deciding on a material?

A.—Not as a rule. In fact it is very seldom that this is necessary. Take an engine lathe bed for instance: It is of a somewhat complicated form, having ribs, sometimes hollow, extending from side to side, bosses and other raised places for attaching parts, and the sides are usually flanged or ribbed at both top and bottom to give rigidity. This form makes it necessary that the bed be made of some material that can be cast in molds. The only two materials whose properties and cost is such as to allow them to be considered are cast iron and steel. Steel is the much stronger of the two, but is more difficult to machine and offers difficulties of casting, as well as greater cost. Since the mass of metal necessary to give the required weight and rigidity will also give sufficient strength, the cheaper and more easily worked cast iron is the more desirable. Table 1, taken from Jones'

"Machine Design," will be found of assistance in deciding on materials for certain parts.

Material	Tensile strength	Compressive strength	Shock resisting power	Methods of shaping for use
Cast iron	Low	Very high	Low	Casting.
Wrought iron, also called malleable iron.	Medium	Medium	High	Rolling, forging, and wire-drawing
Bessemer and open-hearth steel, also called machinery steel, soft steel, mild steel and ingot iron.	High	High	High	Rolling, forging, and wire-drawing.
Crucible steel, also called cast steel and tool steel.	Very high	Very high	Medium	Rolling, forging, and wire-drawing.
Steel castings	High	High	High	Casting.
Malleableized castings, also called malleable iron castings.	Medium	High	High	Casting.
Brass	Medium to low.		Medium	Casting, rolling, forging, and wire-drawing.
Bronze	Medium to low.		Medium	Casting, rolling, forging, and wire-drawing.
Babbitt metal and other grades of white metal used for lining journal boxes.	Very low			Casting.

TABLE 1.—GENERAL PROPERTIES AND METHODS OF WORKING THE MATERIALS MOST COMMON TO ENGINEERING CONSTRUCTION.

151. *Q.*—Next to the selection of a cheap, easily machined material of sufficient strength for the purpose, what is important to remember in the design?

A.—To so arrange the parts that they may be finished without too much difficulty or without the making of special tools, if possible, both of which add greatly to the cost of manufacture.

152. *Q.*—Where is it necessary to use wrought iron or mild steel, which must be fire welded, what can be taken as the per cent. of efficiency?

A.—From 80 to 85 per cent. of the strength of the original bar.

153. *Q.*—What can safely be taken as the efficiency of electrically welded joints on the same material?

A.—About 85 to 90 per cent.

154. *Q.*—What is the efficiency of spur gearing?

A.—This is given in Table 2, by Wilfred Lewis, the table also giving that of spiral and worm gearing:

The excessive friction of worm and spiral gearing is largely due to the end thrust on the collars of the shafts, which may be reduced by the use of roller bearing collars.

Gearing	Pitch	Velocity at pitch-line in feet per minute				
		3	10	40	100	200
Spur pinion	....	0.90	0.935	0.97	0.98	0.985
Spiral pinion	45°	0.81	0.87	0.93	0.955	0.965
Spiral pinion	30	0.75	0.815	0.89	0.93	0.945
Spiral pinion	20	0.67	0.75	0.845	0.90	0.92
Spiral pinion	15	0.61	0.70	0.805	0.87	0.90
Spiral pinion or worm	10	0.51	0.615	0.74	0.82	0.86
Spiral pinion or worm	7	0.43	0.53	0.72	0.765	0.815
Spiral pinion or worm	5	0.34	0.43	0.60	0.70	0.765

TABLE 2.—EFFICIENCY OF SPUR, SPIRAL, AND WORM GEARING.

155. *Q.*—Is the efficiency of bevel gearing equal to that of spur gearing?

A.—No. It is less for the reason that the tooth pressure causes end thrust on the collars.

156. *Q.*—What holding power has a setscrew of a given size?

A.—According to a series of tests by Prof. Lanza, on a pulley held in place on a 11/16-in. shaft by two 5/8-in. setscrews, having ten threads to the inch, the results were as shown in Table 3. The screws were tightened with a force of 75 lb. applied at the end of a 10-in. wrench. The screws were of wrought iron. The shaft was of rather hard steel and the screws made but little impression.

	A Flat ends 9/16 in. dia.	B End rounded to 1/2 in. radius	C End rounded to 1/4 in. radius	D End cupped and case-hardened
Lowest holding power, pounds	1412	2747	1902	1962
Highest holding power, pounds	2294	3079	3079	2958
Mean holding power, pounds	2064	2912	2573	2470

TABLE 3.—HOLDING POWER OF SET SCREWS.

157. *Q.*—How deep should screws or studs be screwed into a casting?

A.—From 1 1/4 to 1 1/2 times their diameter.

158. *Q*—What distance should a stud be from the edge of the metal?

A.—Not less than 0.7, and preferably the full diameter of the stud.

159. *Q*—How far apart should studs or bolts be for flanges subject to medium pressures?

A.—Not more than 5 times the diameter of the bolts.

160. *Q*.—What should be the thickness of covers or flanges?

A.—Not less than the diameter of the retaining bolts.

161. *Q*.—What are the proper proportions of box couplings?

A.—The diameter of the coupling should be from 1 3/4 to 2 times the diameter of the shaft, and the length should be from 2 1/2 to 3 times the diameter of the shaft.

162. *Q*.—What are suitable included angles for cone clutches?

A.—For free engagement, not less than 20 deg. For automobile service 25 deg. For wood on metal 36 to 40 deg.

163. *Q*.—What is the formula for the horse-power capacity of a cone clutch?

$$A.—P.=C\frac{d^2b\times\text{r.p.m.}}{40,120}$$

Here d = mean diameter of friction surfaces in inches.

b = actual width of friction surfaces in inches.

C = a constant = 10 for wood on iron; 12 to 14 for leather on metal; and 2.5 for leather-faced clutches in automobile service.

164. *Q*.—What should be the shortest center distance between two pulleys driven by a belt.

A.—For best results it should never be less than 2 1/2 times the diameter of the large pulley, when the small one is not less than 1/3 of the larger.

165. *Q*.—How should the ends of double universal joints be set to drive evenly?

A.—The pins in the ends of the connecting rod should be parallel, and not at right angles to each other.

166. *Q*.—What are the tolerances for clearance between journal and bearing?

A.—These are given, according to the Brown & Sharpe practice, in Tables 4, 5, 6 and 7.

To 1/2-in. diameter, inc.	0.00025 to 0.00075	Small
To 1 -in. diameter, inc.	0.00075 to 0.0015	Small
To 2 -in. diameter, inc.	0.0015 to 0.002	Small
To 3 1/2-in. diameter, inc.	0.0025 to 0.0035	Small
To 6 -in. diameter, inc.	0.0035 to 0.005	Small

TABLE 4.—RUNNING FITS—ORDINARY SPEED.

To 1/2-in. diameter, inc.	0.0005 to 0.001	Small
To 1 -in. diameter, inc.	0.001 to 0.002	Small
To 2 -in. diameter, inc.	0.002 to 0.003	Small
To 3 1/2-in. diameter, inc.	0.003 to 0.0045	Small
To 6 -in. diameter, inc.	0.0045 to 0.0065	Small

TABLE 5.—RUNNING FITS—HIGH SPEED, HEAVY PRESSURE AND ROCKER SHAFTS.

To 1/2-in. diameter, inc.	0.00025 to 0.0005	Small
To 1 -in. diameter, inc.	0.0005 to 0.001	Small
To 2 -in. diameter, inc.	0.001 to 0.002	Small
To 3 1/2-in. diameter, inc.	0.002 to 0.0035	Small
To 6 -in. diameter, inc.	0.003 to 0.005	Small

TABLE 6.—SLIDING FITS.

To 1 -in. diameter, inc.	Standard to 0.00075	Large
To 2 -in. diameter, inc.	Standard to 0.001	Large
To 3 1/2-in. diameter, inc.	Standard to 0.0015	Large
To 6 -in. diameter, inc.	Standard to 0.002	Large
To 12 -in. diameter, inc.	Standard to 0.0025	Large

TABLE 7.—GRINDING LIMITS FOR HOLES.

167. *Q.*—What is the maximum shaft speed for oil ring lubrication?

A.—2500 r.p.m.

168. *Q.*—What is the greatest distance plain oil rings can distribute oil?

A.—Four inches.

169. *Q.*—What is a good proportion for oil rings?

A.—Diameter of ring twice journal diameter, and submerged in oil one-half diameter of journal.

170. *Q.*—What oil pressure is used for forced lubrication?

A.—From 15 to 25 lb.

171. *Q.*—What are the common dimensions for oil grooves?

A.—3/32 in. to 1/4 in. in width, and 3/32 to 1/8 in. in depth.

172. *Q.*—What are good proportions for babbitt anchors?

A.—Along the straight lips of each half of the bearing the anchors should be fairly close together, and as near the edge as they can be cast, so that when the casting is finished, the anchor holes will break through. In Fig. 16 is given the spacing.

173. *Q.*—What are the relative values of different methods of lubrication?

A.—The following table taken from "Bearings and Their Lubrication" gives:

Bath	Saturated pad	Ordinary pad	Syphon
1	1.32	2.21	4.2

The numerical quantities indicate the frictional resistances referred to the best—bath lubrication—as 1.

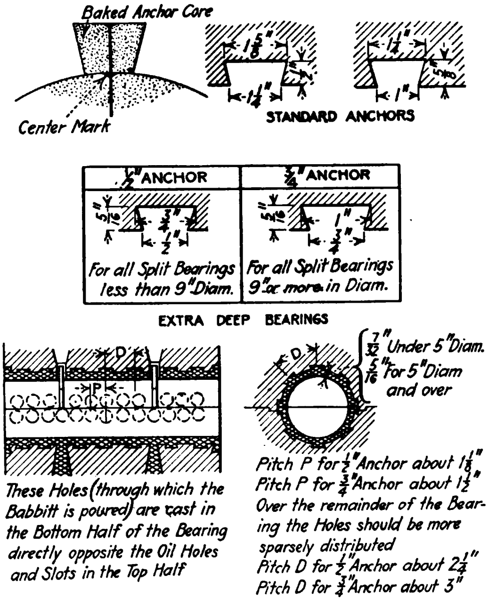

Baked Anchor Core
Center Mark
$1\frac{5}{8}$"
$1\frac{1}{4}$"
$\frac{1}{2}$
$1\frac{1}{4}$"
1"
$\frac{5}{16}$
STANDARD ANCHORS
$\frac{1}{2}$" ANCHOR
$\frac{5}{16}$"
$\frac{3}{4}$"
$\frac{1}{2}$"
For all Split Bearings less than 9" Diam.
$\frac{3}{4}$" ANCHOR
$\frac{5}{16}$"
1"
$\frac{3}{4}$"
For all Split Bearings 9" or more in Diam.
EXTRA DEEP BEARINGS
D
P
D
$\frac{7}{32}$" Under 5" Diam.
$\frac{5}{16}$" For 5" Diam and over
These Holes (through which the Babbitt is poured) are cast in the Bottom Half of the Bearing directly opposite the Oil Holes and Slots in the Top Half
Pitch P for $\frac{1}{2}$" Anchor about $1\frac{1}{8}$"
Pitch P for $\frac{3}{4}$" Anchor about $1\frac{1}{2}$"
Over the remainder of the Bearing the Holes should be more sparsely distributed
Pitch D for $\frac{1}{2}$" Anchor about $2\frac{1}{4}$"
Pitch D for $\frac{3}{4}$" Anchor about 3"

FIG. 16. SIZE AND PITCH OF BABBITT ANCHOR.

174. *Q*—With forced feed where is the proper point to introduce the lubricant?

A.—According to the same authority at a point underneath, 45 deg. from the vertical, with the shaft rotating so as to carry the lubricant first downward and then up over it.

175. *Q.*—What is a good working strength for chains?

A.—$D^2 \times 80$ = Safe working load in pounds, where D = diameter of chain in 1/16 in.

176. *Q.*—What size of rivets should be used to hold plates of a certain thickness together?

A.—Let t = thickness of plate. Then diameter of rivet = $1.25 \sqrt{t}$.

177. *Q.*—What overlap should the plates have for certain size rivets?

A.—1.7 times the diameter of the plates up to 7/8 in. diameter and above that 1.5 times the diameter.

178. *Q.*—What distance is allowed between rows of rivets in a double-riveted joint?

A.—It is twice the diameter of the rivets, center to center, the rivets being staggered.

179. *Q.*—What is the proper length of the bushing and gland for the stuffing box on an engine or pressure pump?

A.—The length of the gland should be 1 1/2 times the diameter of the piston rod for rods up to 1 in. and 1 1/4 times for those above that. The length of the bushing should be 1 3/4 times the diameter of the piston rod up to 1 in. and 1 1/2 times the diameter over that.

180. *Q.*—In designing a jig or fixture, what are important points to keep in mind?

A.—Simplicity, wearing qualities, low cost of making and ease of insertion and removal of work.

CHAPTER V

MATERIALS USED IN MACHINE BUILDING

181. *Q.*—What materials are commonly used in machine construction?

A.—Cast iron, malleable iron, wrought iron, steel, brass, bronze, babbitt, aluminum, fiber and wood.

182. *Q.*—What is cast iron?

A.—It is an impure mixture, the ingredients of a typical example containing approximately 94 per cent. iron, 4 per cent. carbon and 2 per cent. of other ingredients, among the latter being silicon, phosphorous, and occasionally sulphur and manganese.

183. *Q.*—What are some of the advantages of cast iron?

A.—It is easily melted; has little shrinkage; seldom checks in cooling; resists compressive strains well; is comparatively cheap, and may be made into intricate forms easily. Its properties can also be easily changed to give varying degrees of hardness or other qualities, by using different proportions of a few ingredients.

184. *Q.*—What are some of its disadvantages?

A.—Weakness, lack of ductility and lack of malleability. It must be melted and cast into molds to obtain the desired form, as it cannot be bent or hammered into shape and should not, as a rule, be used where subject to violent shocks.

185. *Q.*—What is air furnace iron?

A.—As distinguished from ordinary cupola cast iron, it is more uniform, cleaner and has a higher ultimate strength.

186. *Q.*—What is chilling iron?

A.—It is a cast iron high in carbon, intended to be cast in a mold having "chills" or metal plates set into it, so as to chill or harden one or more surfaces of the casting, making these parts extremely hard, highly resistant to wear, and difficult to machine, while the rest of the casting is comparatively soft.

187. *Q.*—What is vanadium cast iron?

A.—It is an iron to which a small amount, say 0.15 per cent., of ferrovanadium has been added, which greatly increases its strength and wearing qualities.

188. *Q.*—What is gun iron?

A.—It is a special mixture of iron, melted in a cupola, and possessing great ductility and strength, used by the Government for gun carriage work. Originally irons with the desired properties were only obtained in the air furnace.

189. *Q.*—What is cam iron?

A.—It is a hard, close-grained mixture used for making cams for various machines.

190. *Q.*—What is a good formula for cam iron?

A.—One part soft foundry iron; 1 part No. 4 (high) carbonate iron, and 4 parts No. 3 carbonate iron.

191. *Q.*—What are malleable iron castings?

A.—Malleable iron castings are made in molds, using a special mixture of cast iron. The castings are then cleaned and subjected to a red heat for over 60 hours, which leaves them soft, tough and capable of enduring considerable bending or shaping.

192. *Q.*—What are malleable castings used for?

A.—Agricultural implements, railway supplies, carriage and harness castings, pipe fittings and parts where the high tensile strength of steel is not needed, yet the brittleness of cast iron must be avoided.

193. *Q.*—What is wrought iron?

A.—It is refined pig iron. In pig iron the carbon may reach 3 or 4 per cent., while in wrought iron it is under 0.1 per cent. The reduction is accomplished by various means of oxidizing. The iron is very resilient, and consequently well adapted to resisting shocks. It can be easily welded, making a good strong joint if properly handled.

194. *Q.*—What is semi-steel?

A.—As the name implies, it is about half way between cast iron and steel. The mixture formulas vary, but most of them include from 10 to 40 per cent. of steel scrap. It is frequently used for rolls, gears, pinions or other parts requiring considerable strength. One great trouble with castings of this nature in the past has been the tendency to be porous.

195. *Q.*—What is steel?

A.—Ordinary steel differs from wrought iron, in the per cent. of carbon it contains, and in the process of manufacture. Structural or merchant steels range in carbon from 0.08 per cent. to 0.3 per cent. and are classed as mild or soft, medium and hard, according to the number of "points" of carbon it contains, a point being 1/100 per cent. Up to 15 points of carbon it is soft; 15 to 30, medium, and above that it is hard. From these grades of steel the following shapes are rolled hot: rounds, squares, flats, plates, billets, blooms, I-beams, channels, angles, Z-bars and the like.

196. *Q.*—What is machinery steel?

A.—Hot-rolled bar steel, ranging from 12 to 30 points carbon, is commonly known as machinery steel.

197. *Q.*—What is cold-rolled steel?

A.—Steel like the above, which is rolled hot until close to the required size, when it is finished cold. This process produces a section accurately, of the desired dimension, and as it is burnished, it needs no further machining for many purposes, such as shafts, boring bars and rods of various kinds. Cold rolling increases the tensile and traverse strength, and also the elastic limit, but reduces the ductility somewhat.

198. *Q.*—What is Bessemer steel?

A.—It is a steel used both for castings and for bars, and is made by the process after which it is named.

199. *Q.*—What is Tropenas steel?

A.—It is a steel used for steel-casting work, melted in a Tropenas converter.

200. *Q.*—What is crucible steel?

A.—This is a high carbon steel, also known as tool steel or cast steel. It is easily hardened by heating to a cherry red and quenching in water or oil, and it is used for many kinds of cutting tools, hammers, dies and the like. It is sometimes used for castings, but is generally used from the bar and machined to shape.

201. *Q.*—What is meant by "alloy" steel?

A.—According to the International Committee on the Nomenclature of Iron and Steel, it is steel that owes its properties chiefly to the presence of an element other than carbon. However, the presence of certain elements in such low percentage as not to materially affect its properties does not necessarily make it an alloy steel, even though a greater quantity of the same element does. For instance, manganese in amounts of 1.5 per cent. or less is added to all Bessemer and open-hearth steels to get rid of oxygen and neutralize sulphur, but when added in amounts equal to 10 to 20 per cent. it gives new properties to the mixture which is then classified as an alloy steel.

202. *Q.*—What is manganese steel?

A.—It is an alloy steel which ordinarily contains 1.25 to 2 per cent. carbon and from 12 to 13 per cent. of manganese. It is, when properly mixed, of great hardness, which cannot be materially lessened by annealing; of great tensile strength, toughness and ductility. While it is machined with the greatest difficulty, grinding being the only satisfactory method, it may be twisted into the most fantastic shapes, and rivets made of it may be headed cold with comparative ease. It is used for jaws and working parts of rock crushing machinery, mine car wheels, railroad frogs and crossings, teeth on steam shovels and the like. Owing to the difficulty of machining it, it must be ordinarily formed by casting, as it is forged with difficulty. It is non-magnetic and has the peculiar property of slightly softening when heated and suddenly cooled. Its high rate of shrinkage (about 5/16 in. per foot) prevents the making of complicated castings.

203. *Q.*—What is chrome steel?

A.—It is an alloy steel containing from 0.05 to 2 per cent. chromium and from 0.80 to 2 per cent. of carbon. It is used for armor piercing projectiles, automobile gears and other parts, and for plow plates, where great hardness and strength are required.

204. *Q.*—What other alloy steels are frequently used?

A.—Nickel steel, aluminum steel, vanadium steel, nickel-vanadium steel, tungsten steel and several others.

205. *Q.*—What is tungsten steel?

A.—It is a name applied to a number of mixtures known as Mushet, self hardening, high speed or other steels. One sample of Mushet's special steel contained 8.3 per cent. tungsten and 1.73 per cent. manganese.

206. *Q.*—What is "high speed" steel?

A.—This is a name applied in general to all steels used for tools or similar purposes, that contain enough tungsten or molybdenum to enable them to stand up under high-cutting speeds when properly hardened, a cutting speed sufficient to raise the point of a tool to a red heat not being uncommon.

207. *Q.*—What steel is used for drop forgings?

A.—Practically any of the steels may be used for drop forgings, it being more a question of the correct heat than almost anything else. In fact, it is easier to shape the higher alloy steels by drop forging in dies, than to shape them by ordinary forging, owing to the fact that they can generally be finished at one heat.

208. *Q.*—What is brass and what is it used for?

A.—It is a composition of varying proportions of copper and zinc and sometimes a small per cent. of lead. It is used in machinery building for parts of valves or parts where rust would give trouble.

209. *Q.*—What is the difference between brass and bronze, and for what is bronze used?

A.—There is no distinct line, though the predominance of zinc, next to copper, in a mixture, usually classes it as brass, while tin, taken in the same way, classes it as bronze. Bronze is largely used for bearings, valves, pump parts and the like.

210. *Q.*—What is manganese bronze?

A.—It is an alloy, extensively used for propeller blades, but the amount of manganese is exceedingly small, ranging from 0.01 to 0.12 per cent., and sometimes is not in evidence at all. A chip from the propeller blade, of

Vanderbilt's yacht Alva, made of Parson's manganese bronze, analyzed gave: Cu, 88.64; Zn, 1.57; Sn, 8.70; Fe, 0.72; Pb., 0.30; P, trace. It will be noted that no manganese is listed.

211. *Q.*—What is phosphor bronze?

A.—It is a bronze made by adding a small amount of phosphorous to the other ingredients, which has the effect of improving the strength, grain, ductility, color and fluidity.

212. *Q.*—What are the constituents of some of the more common bronzes and bearing metals?

A.—According to C. B. Dudley, these are given in Table 8.

Metal	Copper	Tin	Lead	Zinc	Antimony	Iron
Camelia metal	70.20	4.25	14.75	10.20		0.55
Anti-friction metal	1.60	98.13				trace
White metal			87.92		12.08	
Car brass lining		trace	84.87		15.10	
Salgee anti-friction	4.01	9.91	1.15	85.57		
Graphite-bearing metal		14.38	67.73		16.73	(1)
Antimonial lead			80.69		18.83	
Carbon bronze	75.47	9.72	14.57			(2)
Cornish bronze	77.83	9.60	12.40	trace		trace (3)
Delta metal	92.39	2.37	5.10			0.07
Magnolia metal[1]	trace		83.55	trace	16.45	trace (4)
American anti-friction			78.44	0.98	19.60	0.65
Tobin bronze	59.00	2.16	0.31	38.40		0.11
Graney bronze	75.80	9.20	15.06			
Damascus bronze	76.41	10.60	12.52			
Manganese bronze	90.52	9.58				(5)
Ajax metal	81.24	10.98	7.27			(6)
Anti-friction metal			88.32		11.93	
Harrington bronze	55.73	0.97		42.67		0.68
Carbox metal			84.33	trace	14.38	0.61
Hard lead			94.40		6.03	
Phosphor bronze	79.17	10.22	9.61			(7)
Ex. B. metal	76.80	8.00	15.00			(8)

[1] H. C. Torrey says this is erroneous, as this metal always contains tin.

TABLE 8.—CONSTITUENTS OF COMMON BRONZES AND BEARING METALS.

Other constituents:

(1) No graphite.
(2) Possible trace of carbon.
(3) Trace of phosphorus.
(4) Possible trace of bismuth.
(5) No manganese.
(6) Phosphorus or arsenic.. 0.37.
(7) Phosphorus........... 0.94.
(8) Phosphorus........... 0.20.

213. *Q.*—What are the physical properties of the principal metals previously mentioned?

A.—As given in Table 9.

Material	Modulus of elasticity		Ultimate strength		Elastic strength	
	Tension compression	Torsion	Tension	Shear	Tension	Shear
Cast-iron (cupola)	10,700,000 15,000,000	4,000,000 6,000,000	16,000 20,000	16,000 20,000	8,000	8,000
Cast-iron (air-fur)	....	....	30,000 40,000	....	....	....
Wrought-roni	28,000,000	11,000,000	47,000 57,000	35,000 43,000	....	....
Steel 0.15 carbon	30,000,000	11,800,000	60,000	45,000	40,000	....
Steel 0.25 carbon	30,000,000	11,800,000	70,000	52,000	45,000	....
Crucible steel (high carbon)	31,000,000	12,100,000	100,000	....	75,000	....
Steel castings	30,600,000	11,800,000	50,000 100,000	30,000 60,000	....	....
Copper castings	12,000,000	....	22,000	....	6,000	....
Copper, rolled	16,000,000	....	28,500 33,000	....	....	....
Brass cast., yel	11,400,000	....	22,000	....	....	....
Brass cast., yel., red	12,800,000	....	28,500	....	....	....
Gun-metal	15,400,000	....	42,800	....	....	....
Phosphor bronze	....	....	57,000	....	24,000	....

TABLE 9.—PHYSICAL PROPERTIES OF METALS.

Note.—The ultimate strength of cast-iron in compression is 90,000 to 100,000 lb. per square inch. Its elastic strength in compression can be assumed as 25,000 lb. per square inch. The ultimate compressive strengths of the other materials can be taken as equal to their ultimate tensile strengths without appreciable error.

214. *Q.*—What is babbitt?

A.—It is a bearing metal named after its inventor, the ingredients of which are tin, copper and antimony, and the original proportions are supposed to be:

Tin	Copper	Antimony
89.3	3.6	7.1
83.3	8.3	8.4
89.1	3.7	7.2

It is, when carefully prepared, one of the best metals in use for lining boxes that are subjected to a heavy weight and wear, but for light, fast-running journals the copper renders it more susceptible to friction.

214. *Q.*—What are die castings?

A.—They are castings made in permanent metal molds, into which the metal is forced under pressure. The castings are usually so accurate and well finished as to require very little machining before use. Often they are used just as they come from the mold.

215. *Q.*—What kind of metal is used for die castings?

A.—There are many mixtures used, but a few are given in Table 10.

No.	Tin	Copper	Aluminum	Zinc	Lead	Antimony	Iron
1	14.75	5.25	6.25	73.75	....	....	....
2	19.00	5.00	1.00	72.7	2.00	0.3	....
3	12.00	10.6	3.4	73.8	....	....	0.2
4	30.8	20.4	2.6	46.2	....	....	....

TABLE 10.—MIXTURES USED FOR DIE CASTINGS.

Nos. 1 and 2 are suitable for ordinary work, such as could be performed by average brass castings. Nos. 3 and 4 are harder.

216. *Q.*—What is aluminum used for?

A.—Alloyed with copper, tin, zinc, nickel, iron, manganese, silver or other metals, it is used for various purposes where lightness is desired, as in automobile crank and transmission cases, small machine frames and the like. It is used in the form of castings, sheet, wire and bars.

217. *Q.*—What is fiber used for?

A.—Hard fiber is used for small thrust collars, electrical washers and various insulators.

218. *Q.*—Is wood used to any extent in machine construction?

A.—It is used for frames of textile machinery, pulleys for various purposes and for tailshaft bearings in steamships, or guide bearings of water wheels. For the bearings, lignum vitæ is generally used on account of its dense, greasy nature. For other purposes oak, maple or hickory is usually used.

CHAPTER VI

STANDARDS IN MACHINE BUILDING

219. *Q.*—What is the standard of length in the United States?

A.—The British yard, a duplicate of their standard having been made, which is kept in the U. S. Bureau of Standards for comparison purposes.

220. *Q.*—What is the European (Continental) standard of length?

A.—The meter.

221. *Q.*—How does this compare with the yard?

A.—The yard equals 36 in., and according to act of Congress, the accepted standard for a meter is 39.37 in.

222. *Q.*—What is the standard of weight in the United States and in Europe?

A.—In the United States the pound and in Europe the gram.

223. *Q.*—How do these compare?

A.—One pound equals 453.6 grm.

224. *Q.*—What are the standards of capacity in the United States and in Europe?

A.—The gallon and the liter, the gallon being equal to 3.78 liters, or 231 cu. in.

225. *Q.*—What are the standard screw threads used in machine building?

A.—There are no absolutely fixed standard screw threads in universal use, though the more common in use in the United States are the U. S. Standard or Seller's thread, the A. S. M. E. Standard, Acme, Whitworth, Square and Sharp V.

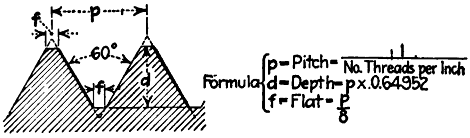


FIG. 17. U. S. STANDARD THREAD FORMULA.

226. *Q.*—What is the U. S. Standard thread?

A.—It is a thread cut to an angle of 60 deg. and flat top and bottom as shown in Fig. 17.

227. *Q.*—What is the A. S. M. E. Standard thread?

A.—The included angle of this thread is 60 deg. and a flat is made top and bottom, equal to one-eighth of the pitch of the basic diameter. For machine screws, the size increases uniformly from 0 to 10 by 0.013 in. and twice that in the remaining sizes. The pitches are a function of the diameter as expressed by the formula:

$$\text{Threads per inch} = \frac{6.5}{D+0.02}$$

The minimum tap conforms to the basic standard in all respects except diameter. The difference between the minimum tap and the maximum screw, provides an allowance for error in pitch, and wear of the tap in service.

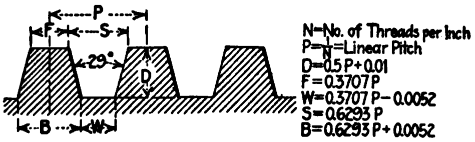


FIG. 18. ACME SCREW THREAD AND FORMULA.

228. *Q.*—What is the Acme thread?

A.—The Acme thread is an adaptation of the worm thread, intended to take the place of the square thread, and is much stronger than the latter.

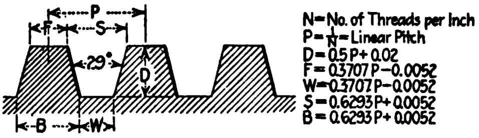


FIG. 19. ACME TAP THREAD AND FORMULA.

The shape and formula are given in Fig. 18. The shape and formula for taps for Acme threads are as shown in Fig. 19.

229. *Q.*—What is the Whitworth thread?

A.—The shape and dimensions are as indicated in Fig. 20.

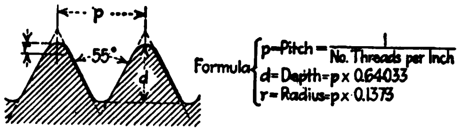


FIG. 20. WHITWORTH THREAD AND FORMULA.

230. *Q.*—What is the Briggs thread?

A.—It is the standard pipe thread used in this country. It has an angle of 60 deg. and is slightly rounded, so that the depth of the thread is four-fifths of the pitch. The taper employed in cutting taps or dies has an inclination of 1 in 32 to the axis.

231. *Q.*—Are there standard sizes of set, machine and cap screws?

A.—Yes. They may be found by reference to the catalog of almost any firm listing them.

232. *Q.*—Are lag and coach screws, wood screws, washers and nuts standardized?

A.—Yes. Reference as above.

233. *Q.*—What are the standard sizes of shafting?

A.—Sizes for cold-rolled steel shafting increase regularly in size by 1/16 in. from 1 1/2 to 3 in., but from there on the sizes do not increase uniformly.

234. *Q.*—What standards of measurement are used for drill rod?

A.—Brown & Sharpe wire gage and Stubbs steel wire gage are the more generally used.

235. *Q.*—What are the standard sizes for taper pins?

A.—The taper, according to Pratt & Whitney, is 1/4 in. to the foot and the sizes are well defined in their tables. The taper and split pins used by the U. S. Ordnance Department are given herewith:

236. *Q.*—What are the tapers used for lathe and miller centers, arbors, drill shanks and the like?

A.—Morse, Brown & Sharpe, Reed, Sellers and Jarno.

237. *Q.*—What is the taper per foot in the Morse standard?

A.—It varies with each size, being for No. 0 size, 0.625 in. per foot; No. 1, 0.600 in.; No. 2, 0.602 in.; No. 3, 0.602 in.; No. 4, 0.623 in.; No. 5, 0.630 in.; No. 6, 0.626 in.; and No. 7, 0.625 in. This taper is usually used for drill shanks.

STANDARD TAPER PINS

0.25 per Ft. Taper and Retaining Split Pins

TAPER PINS		WORK			SPLIT PINS	
DIA. AT SMALL END		USED IN SHAFTS		COLLARS	DIAM.	LENGTH
Number	D	Min. Diam.	Max. Diam.	Max. Diam.		
	0.0625		0.3	0.75		
	0.09375	.0.3	0.5	1		
0	0.135	0.5	0.75	1.125	0.0468	0.3125
2	0.162	0.75	1	1.625	0.0625	0.375
4	0.208	1	1.5	2.125	0.0781	0.4375
6	0.279	1.5	2	3.25	0.09375	0.5
8	0.398	2	3	4.875	0.125	0.75
10	0.581	3	4.5	6.625	0.156	1
12	0.842	4.5	6.5	9.625	0.203	1.25

STANDARD SPLIT PINS

DIAM.	LENGTHS MANUFACTURED														
0.0468	0.3125	0.5													
0.0625	0.375	0.5625	0.75												
0.0781	0.4375	0.625	0.8125	1				ALL PINS BELOW THIS LINE							
0.09375	0.5	0.75	1	1.25	1.5	1.75	2	ARE COMMERCIAL SIZES							
0.125	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5						
0.156	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5						
0.203		0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3				
0.25			1	1.25	1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75	4
0.375					1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75	4
0.5	Also 5 and 6 inch.						2	2.25	2.5	2.75	3	3.25	3.5	3.75	4
0.625	Also 5 and 6 inch										3	3.25	3.5	3.75	4

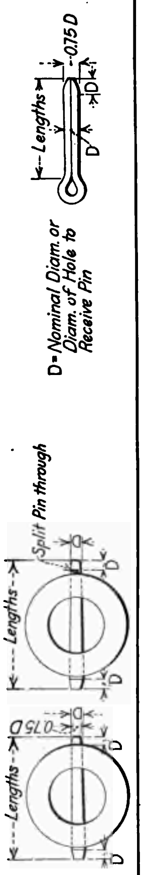


FIG. 21. STANDARD TAPER PINS USED BY THE U. S. ORDNANCE DEPARTMENT.

238. *Q*.—What are the tapers per foot in Brown & Sharpe, Reed, and Sellers standards?

A.—For Brown & Sharpe, 0.500 in. per foot; Reed, 0.6 in. per foot, and Sellers, 3/4 in. per foot.

239. *Q*.—What is the Jarno taper and what is the taper per foot?

A.—In this system, which is used by Pratt & Whitney, Norton Grinding Co., and others, the taper is 0.6 in. per foot, or 1 in 20. The number of the taper is the key by which all the dimensions are immediately determined without the necessity of referring to a table, as the number of the taper is the number of tenths per inch in diameter at the small end; the number of eighths of an inch at the large end; and the number of halves of an inch in length or depth. For example: No. 6 taper is six-tenths of an inch in diameter at the small end, six-eighths (3/4) inch at the large end and six halves (3) inches in length. Formulas are as follows:

Taper per foot = 0.6. Taper per inch = 0.05 in.

$$\text{Dia. small end} = \frac{\text{No. of taper}}{10}$$

$$\text{Dia. large end} = \frac{\text{No. of taper}}{8}$$

$$\text{Length of taper} = \frac{\text{No. of taper}}{2}$$

240. *Q*.—What is the angle of a lathe center?

A.—Sixty degrees.

241. *Q*.—What sizes of tool steel are commonly used for lathe, shaper and planer tools in the average machine shop?

A.—For solid forged tools, 1/2×1 in., 5/8×1 1/2 in., 3/4×1 1/2 in., and 1×2 in., the length varying. For use in toolholders, 1/4, 5/16, 3/8 and 1/2 square by 2 or 3 in. in length.

242. *Q*.—Is there a uniform or standard angle for V-ways of a lathe or planer?

A.—No, the practice varies with nearly every make. Nor is there any uniformity as to the use of V's and flat ways or combinations of them.

243. *Q*.—Is there a standard system of change gearing in use whereby various makes of lathes can be made to cut a certain range of threads?

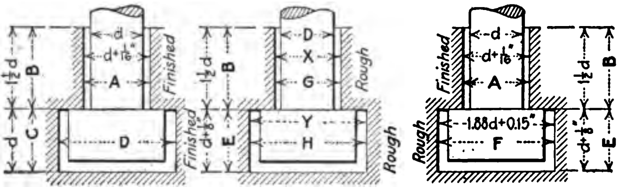
A.—No.

244. *Q*.—What standards of gear teeth are in use?

A.—A majority of the gears cut have what is known as standard involute teeth, with a pressure angle of 14 1/2 deg., though the Sellers gear with a pressure angle of 20 deg. and the same length of tooth, is often used. There are also a number of stub-toothed gears in use, the Fellows having a pressure angle of 20 deg.

245. *Q.*—What are the standard sizes of T-slots?

A.—There are none in universal use at present, though William Sellers & Co. produced one in 1883, which with slight modifications made in 1908, is given in Fig. 22.

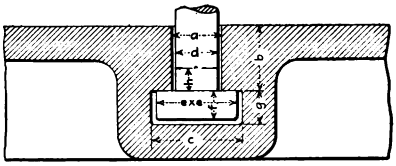


d	A	B	C	D	E	F	G	H	X	Y
1/2"	9/16"	3/4"	1/2"	1"	5/8"	1 1/16"	9/16"	1"	d+1/16"	1.5d+1/4"
5/8"	11/16"	15/16"	5/8"	1 3/16"	3/4"	1 5/16"	11/16"	1 3/16"	d+1/16"	1.5d+1/4"
3/4"	13/16"	1 1/8"	3/4"	1 3/8"	7/8"	1 9/16"	7/8"	1 7/16"	d+1/8"	1.5d+5/16"
7/8"	15/16"	1 5/16"	7/8"	1 9/16"	1"	1 13/16"	1"	1 5/8"	d+1/8"	1.5d+5/16"
1"	1 1/16"	1 1/2"	1"	1 3/4"	1 1/8"	2"	1 1/8"	1 13/16"	d+1/8"	1.5d+5/16"
1 1/8"	1 3/16"	1 11/16"	1 1/8"	1 15/16"	1 1/4"	2 1/4"	1 1/4"	2"	d+1/8"	1.5d+5/16"
1 1/4"	1 5/16"	1 7/8"	1 1/4"	2 1/8"	1 3/8"	2 1/2"	1 3/8"	2 3/16"	d+1/8"	1.5d+5/16"
1 3/8"	1 7/16"	2 1/16"	1 3/8"	2 5/16"	1 1/2"	2 3/4"	1 1/2"	2 3/8"	d+1/8"	1.5d+5/16"

FIG. 22. SELLERS' STANDARD SIZES OF T-SLOTS.

246. *Q.*—Are there any other standards for T-slots in use?

A.—Carl G. Barth devised the table Fig. 23 which is in use at the Watertown Arsenal.



DIMENSIONS FOR STANDARD T-BOLTS AND SLOTS

DIMENSION	FORMULA FOR DIMENSION	DIAMETER OF BOLTS																				
		3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4
a	d + 1/16	7/16	1/2	9/16	11/16	13/16	15/16	1 1/16	1 3/16	1 5/16	1 7/16	1 9/16	1 11/16	1 13/16	1 15/16	2 1/16	2 5/16	2 9/16	2 13/16	3 1/16	3 9/16	4 1/16
b	1 1/2 d	9/16	21/32	3/4	15/16	1 1/8	1 5/16	1 1/2	1 11/16	1 7/8	2 1/16	2 1/4	2 7/16	2 5/8	2 13/16	3	3 3/8	3 3/4	4 1/8	4 1/2	5 1/4	6
c	1 7/8 d + 3/16	7/8	1	1 1/8	1 11/32	1 19/32	1 13/16	2 1/16	2 9/32	2 17/32	2 3/4	3	3 7/32	3 15/32	3 11/16	3 15/16	4 11/32	4 7/8	5 1/4	5 13/16	6 3/4	7 3/4
e	1 3/4 d + 1/16	23/32	27/32	15/16	1 5/32	1 3/8	1 19/32	1 13/16	2	2 1/4	2 3/8	2 11/16	2 3/4	2 15/16	3 1/8	3 5/16	4 1/8	4 3/8	4 7/8	5 5/16	6 1/4	7 1/16
f	5/8 d + 1/16	9/32	11/32	3/8	15/32	17/32	19/32	11/16	3/4	13/16	7/8	1	1 1/32	1 1/8	1 7/32	1 5/16	1 15/32	1 5/8	1 25/32	1 15/16	2 1/4	2 9/16
g	11/16 d + 1/8	3/8	13/32	15/32	17/32	5/8	23/32	13/16	29/32	1	1 3/32	1 3/16	1 9/32	1 11/32	1 13/32	1 1/2	1 21/32	1 27/32	1 7/8	2 3/16	2 1/2	2 7/8
h	7/16 d + 1/16	7/32	1/4	9/32	11/32	3/8	7/16	1/2	9/16	5/8	21/32	23/32	3/4	13/16	7/8	15/16	1 1/16	1 5/32	1 1/4	1 3/8	1 19/32	1 13/16

SIZE OF SLOTS

FIG. 23. BARTH STANDARDS FOR T-SLOTS.

247. *Q.*—What are the standard sizes for straight and square keys and keyseats?

A.—Jones & Laughlin, Pittsburgh, has a standard; other companies use others, but probably the most concise is that of Baker Bros., Toledo, O., giving rules as follows: The width of the key should equal one-sixth diameter of the shaft. The depth in the hub should be one-half the thickness of the key.

248. *Q.*—What is the standard of taper for taper keys?

A.—According to Jones & Laughlin, the taper is 1/8 in. per foot. According to Baker Bros., the dimensions are as follows: The taper should be 3/16 in. per foot. The depth in the hub at the large end, for a taper keyseat, should be three-fifths the thickness of the key.

249. *Q.*—What is the standard "crown" for a pulley?

A.—Practice varies. Usually it is from 1/10 to 1/8 for a 24-in. face.

250. *Q.*—What ratios of progression are usually used for speeds and feeds in the common machine tools?

A.—They are commonly arranged in geometrical progression, except in the case of the drilling machine on which the arithmetical progression is more suitable.

251. *Q.*—Are there any recommended ratios for geometrical progressions of feeds and speeds?

A.—Yes. Carl G. Barth recommends a leading ratio of 2 and a secondary ratio of 1.189.

252. *Q.*—Is there a standard of actual speed or feed in use?

A.—No, the practice varies.

253. *Q.*—Are there any standards for the use of ball bearings in machines?

A.—Yes. Table 11 has been abstracted from a report of the Standards Committee of the Society of Automobile Engineers. It should be borne in mind that the capacities given are based on ball bearings of suitable material and workmanship, running at a uniform speed and uniform radial load, the speed not exceeding 500 r.p.m. Only the number of the bearing and the load capacity are given, as the other dimensions are easily obtained from any good catalog.

254. *Q.*—Are there any standard methods of obtaining the proper sizes of roller bearings to use?

A.—Yes. For Hyatt flexible roller bearings, for low speeds up to 50 r.p.m., the maximum limit lies between 400 and 500 lb. per square inch of projected journal area. With increase of speed, allowable pressure decreases. For lineshaft bearings up to 3 15/16 in. in diameter, running up to 600 r.p.m., 30 lb. per square inch is considered good practice. For larger shafts, the same factor is allowable up to 400 r.p.m. High duty bearings carry much greater unit loads. A rating of 750 lb. per square inch at 1000 r.p.m. is conservative.

Light loads		Medium loads		Heavy loads	
No.	Radial load in pounds	No.	Radial load in pounds	No.	Radial load in pounds
200	120	300	200	403	850
201	140	301	240	404	1,050
202	160	302	280	405	1,320
203	250	303	370	406	1,600
204	320	304	440	407	1,900
205	350	305	620	408	2,200
206	550	306	860	409	2,500
207	600	307	1,100	410	3,400
208	860	308	1,450	411	3,900
209	950	309	1,750	412	4,400
210	1,000	310	2,100	413	4,900
211	1,160	311	2,400	414	6,200
212	1,550	312	2,800	415	6,600
213	1,670	313	3,300	416	7,300
214	1,820	314	4,000	417	8,580
215	2,130	315	4,400	418	10,000
216	2,650	316	5,000	419	11,880
217	2,850	317	5,700	420	14,000
218	3,400	318	6,400		
219	3,750	319	7,000		
220	3,950	320	7,700		
221	4,600	321	8,400		
222	5,000	322	10,000		

TABLE 11.—LOADS FOR BALL BEARINGS OF VARIOUS SIZES.

A limiting maximum speed for the standard or commercial bearings is about 1500 r.p.m. and for high duty bearings, 3000 r.p.m. The formula for the capacity for solid roller journal bearings used by the Standard Roller Bearing Co. is as follows:

$$130{,}000\,\frac{d^2nl}{3\,S}=\text{capacity in pounds.}$$

d = diameter of rollers in inches.
n = number of roller.
l = length of each roller in inches.
S = circumferential speed of each roller in feet per minute.

The same company's formula for conical roller journal bearings is:

$$130{,}000\,\frac{d^2nl}{3\,S}$$

d = mid-diameter of roller in inches.
n = number of rollers.
l = contact length of a roller with its bearing washer in inches.
S = mean circumferential speed of each roller in feet per minute.

For thrust bearings the formula is:

$$100{,}000\,\frac{d^2M}{S} = \text{load capacity in pounds.}$$

In which d = diameter of rollers in inches.
M = sum of lengths of all the rollers in inches.
S = the mean circumferential speed of the rollers in feet per minute.

CHAPTER VII

POWER AND MOTORS FOR MACHINE TOOLS

255. *Q.*—What are the two common methods of transmitting power.

A.—By mechanical means, and by electrical means.

256. *Q.*—What is meant by mechanical means?

A.—The using of shafting connected by belt or rope drives. The engine usually drives to a jackshaft which in turn connects with shorter jackshafts on the various floors and they in turn with the main lineshafts. In a multi-storied building the belt tower is frequently found. This is a well running the full height of the building in which are installed a series of vertical belts running from floor to floor and driving a jackshaft on each floor from which secondary driving belts reach out to the main line shafting.

257. *Q.*—What are the two methods of electric driving of machine tools?

A.—The group system and individual motors.

258. *Q.*—What is meant by group driving?

A.—The driving of a length of shafting by a motor from which a number of machine tools are belted.

259. *Q.*—What kind of motors are used, for this work?

A.—Both direct-current and induction motors are used, although the latter is preferable. The induction motor is especially a constant-speed motor and in group driving there is usually no reason to change the speed of the lineshafting.

260. *Q.*—What are common voltages?

A.—Common voltages for direct-current motors are 110 and 220 volts; for induction motors 440 and 550 volts.

261. *Q.*—What are common horse-power sizes for group drive motors?

A.—From 5 to 75 h.p. with favorite sizes of 20, 30 and 40 h.p. Group driving implies small departments which in turn call for small motors.

262. *Q.*—How are such motors usually installed?

A.—A common practice places such motors on the ceiling where it is possible, or on a support so that they are 6 or 7 ft. above the floor. This brings them away from the danger of accidental injury and further protects the workmen from coming in contact with them.

263. *Q.*—That is meant by individual driving of machine tools?

A.—The furnishing of one motor to drive a particular machine tool, this motor being selected for the particular kind of service to be performed.

264. *Q.*—What are the advantages of individual driving?

A.—These are set forth in Table 12 reproduced from a paper by Charles Robbins, *Trans. A.S.M.E.*, Vol. 32, page 182.

265. *Q.*—What kind of motors are used for individual driving?

A.—Both direct-current and induction motors. The former for cases where adjustable speeds are required, the latter for constant speed purposes.

266. *Q.*—Are reversing motors used for individual drives?

A.—Reversing motors were first applied to metal planers and have since had a limited application to slotters and boring mills.

267. *Q.*—How are individual motors connected to the machines?

A.—By gearing through chain drives, by belts and occasionally by having the driving shaft of the machine direct connected to or integral with the armature shaft of the motor.

268. *Q.*—What are common voltages?

A.—For direct-current motors 115 and 230 volts. For alternating-current motors 110 and 220 volts.

269. *Q.*—What are common motor sizes for individual drives?

A.—1 1/2 (for direct current only), 2, 3, 5, 7 1/2, 10, 15, 20 and 25 h.p.

270. *Q.*—What are the common speed ranges for adjustable speed motors?

A.—2 to 1, and 3 to 1.

271. *Q.*—What is the common number of cycles for induction motors for individual driving?

A.—60 cycles.

272. *Q.*—What is the common method of driving engine lathes?

A.—Both variable and constant speed motors are used, although in general engine lathes are group driven. Where individual motors are used, each is placed on a bracket attached to the lathe and connected by geared or chain drives.

273. *Q.*—How are forging lathes and very heavy lathes usually driven?

A.—By direct-connected, direct-current motors. The motor should be placed very low to reduce vibration in its support. The output of such lathes may be increased from 20 to 25 per cent. by individual motor drives.

274. *Q.*—How are planers driven?

A.—In the smaller sizes by variable-speed, direct-current motors. In the larger sizes by a number of motors each controlling some particular movement of the machine. A recent development in the reversing motor drive promises success and does away with reversing belts and all of the common reversing mechanisms.

275. *Q.*—How are milling machines of the knee-and-column type driven?

A.—In the smaller sizes, in groups, in the larger sizes by means of variable-speed, direct-current motors, especially used on gang work.

276. *Q.*—How are milling machines of the planer type driven?

A.—These are usually large machines and are preferably driven by either constant-speed or variable-speed motors.

Item	Lineshaft drive	Individual motor drive	Advantage of individual motor
1. Power consumption.	Constant friction loss in shafts, belts and motor, power for cutting.	Friction loss (motor and tool only); useful power only while working.	Less power required.
2. Speed control....	No. speeds = No. cone pulleys × No. gear ratios.	No. speeds = No. controller points × No. gear ratios.	More speeds possible; saved in speed adjustments.
3. Reversing.......	Clutch and crossed belt.	Reversible controller......	Time saved in reversing.
4. Adjusting tool and work.	Stopping at any definite point very difficult.	Can be started in either direction and stopped promptly at any point.	Time saved in setting up and lining up.
5. Speed adjustment.	Large speed-increments between pulley steps.	Small speed increments between controller steps.	Time saved by obtaining proper cutting speed.
6. Size of cut......	Limited by slipping belt; large belts hard to shift.	Limited by strength of tool and size of motor.	Time saved by taking heavier cuts.
7. Time to complete a job.	....	....	Much less time required as indicated for previous items.
8. Liability to accidents.	Slipping or breaking belts; injury to machine tool; cutting tool or prime mover.	Injury to machine tool, cutting tool or motor.	Much less liability to accidents.
9. Checking economy of operations.	Close supervision required; very difficult to locate causes of delay.	Accurate tests possible by means of graphic meter which records automatically all delays and rate of cutting.	Causes of delay and remedies easily located without personal supervision.
10. Flexibility of location.	Location determined by shafting, and changes difficult.	Location determined by sequence of operations; changes readily made.	Greater convenience in handling and increased economy of operation; more compact arrangement possible.

TABLE 12.—COMPARISON OF LINESHAFT DRIVE AND INDIVIDUAL MOTOR DRIVE FOR MACHINE TOOLS.

Kind	Size	Observed horse-power, maximum	Observed horse-power, average	Remarks
BORING MACHINES.				
Bullard, single head	36 in.	0.78	0.52	
Bullard, double head	42 in.	1.72	1.08	
CAM CUTTERS.				
Brainard	No. 2	....	0.67	
Brainard	No. 4	0.48	0.32	
Brainard	No. 5	0.48	0.32	
Lathe type, single head	....	....	0.32	
Lathe type, double head	....	....	0.50	
CUTTING-OFF MACHINES.				
Hurlbut-Rogers	1-15/16 in.	....	0.12	
Hurlbut-Rogers	2 in.	0.28	0.14 to 0.18	
Hurlbut-Rogers	3 in.	0.34	0.20 to 0.22	
DRILLING MACHINES.				
Prentice Bros. radial	No. 0	....	0.72	
Prentice Bros. radial	No. 1	3.18	1.12	
Woodward & Rogers	Sensitive single-spindle	....	0.31	
Dwight-slate	2-spindle		0.32	
Woodward & Rogers	Sensitive 3-spindle	....	0.35	
Woodward & Rogers	4-spindle	....	0.48	
Woodward & Rogers	6-spindle	....	0.71	
Prentice upright	16 in.	....	0.25	
Prentice upright	18 in.	....	0.35	
Prentice upright	20 in.	....	0.42	
Prentice upright	22 in.	....	0.59	
Blaisdell upright	24 in.	....	0.47	
Blaisdell upright	26 in.	....	0.22	
Blaisdell upright	28 in.	....	0.25	
Blaisdell upright	30 in.	....	0.30	
Blaisdell upright	34 in.	....	0.45	
Blaisdell upright	36 in.	....	0.53	
Blaisdell upright	46 in.	....	0.63	
Blaisdell upright	50 in.	....	0.83	
GEAR CUTTERS.				
Brainard	No. 4 1/2	....	0.15 to 0.32	
Gould & Eberhardt	No. 3	....	0.20	
Brown & Sharpe	No. 3	....	0.20	
GRINDERS.				
Brown & Sharpe cutter and reamer grinder.	No. 3	....	0.32	
C. H. Besly & Co. Gardner grinder	No. 4	1.42	0.53	
Brown & Sharpe plain	No. 11	....	0.80	
Brown & Sharpe surface	No. 2	....	0.40	
Brown & Sharpe surface	No. 3	....	0.50	
Brown & Sharpe universal	No. 1	....	0.60	
Brown & Sharpe universal	No. 2	....	0.76	
Diamond wet tool grinder	....	3.29	0.97	Carrying one 20-in. wheel.
Leland & Faulconer wet grinder	....	....	0.41 to 0.82	Carrying two 24-in. wheels.

TABLE 13.—POWER VALUES FOR MACHINE TOOLS IN GROUPS.

Kind	Size	Observed horse-power, maximum	Observed horse-power, average	Remarks
DROP HAMMERS.				
Blondell	40 lb.		0.10	
Pratt & Whitney	250 lb.		2.00	
Pratt & Whitney	400 lb.		2.50	
Pratt & Whitney	600 lb.		3.00	
Pratt & Whitney	800 lb.		3.50	
Pratt & Whitney	1000 lb.		4.00	
Billings & Spencer	1500 lb.		5.00	
POWER HAMMERS.				
Bradley	100 lb.		1.50	
Bradley	150 lb.		1.75	
KEYSEATER.				
Baker Bros	No. 4	0.64	0.28 to 0.32	
LATHES.				
Reed boring lathe	20 in.		0.35	
Reed boring lathe	30 in.		0.41	
Reed engine lathe	12 in.		0.24	
Reed lathe	14 in.	0.48	0.26	
Prentice	16 in.		0.34	
Reed	16 in.		0.36	
Blaisdell	18 in.		0.39	
Blaisdell	20 in.		0.44	
Reed	22 in.	0.37	0.32	
Reed	24 in.		0.25	
Blaisdell	24 in.		0.31	
Prentice	28 in.		0.31	
Draper	38 in.		0.58	
Reed speed lathe	10 in.		0.10	
Reed speed lathe	14 in.		0.12	
Putnam squaring-up lathe	15 in.		0.25	
Gisholt turret lathe	Size H		0.70	
Potter & Johnston semi-automatic	No. 1	1.63	0.33 to 0.63	
Jones & Lamson flat turret	2×24 in.	1.97	1.20 to 1.80	
Wood turning lathe	14 in.		0.31	
Wood turning lathe	16 in.		0.36	
Wood turning lathe (Putnam gap)	36 in.	1.50	1.30	
MILLING MACHINES.				
Brainard	No. 1	0.47	0.30	
Brainard	No. 3	0.64	0.26	
Brainard	No. 4		0.19 to 0.29	
Brainard	No. 4 1/2		0.13 to 0.19	
Brainard	No. 6		0.26	
Brainard	No. 7		0.83	
Brainard	No. 14		0.25	
Brainard	No. 15		0.25	
Becker vertical	No. 3		0.26	
Becker vertical	No. 5		0.55	
Becker-Brainard	No. 3		0.17 to 0.25	
Brown & Sharpe	No. 1		0.15	
Brown & Sharpe	No. 2		0.25	
Brown & Sharpe	No. 5		0.30	
Reed	No. 7		0.83	
Pratt & Whitney hand	No. 1 1/2		0.20	

TABLE 13.—POWER VALUES FOR MACHINE TOOLS IN GROUPS. *Continued.*

Kind	Size	Observed horse-power, maximum	Observed horse-power, average	Remarks
PLANERS.				
Whitcomb	17 in.	2.01	1.00 to 0.43	
Whitcomb	22 in. × 5 ft.	2.34	1.16 to 0.53	
Putnam	22 in. × 5 ft.	1.44	0.70	
Putnam	24 in. × 6 ft.	....	0.84	
Putnam	26 in. × 5 ft.	1.59	0.81	
Putnam	30 in. × 6 ft.	4.91	1.31	
Putnam	30 in. × 8 ft.	5.46	1.56	
Powell	36 in. × 10 ft.	4.00	1.60	
Pond	50 in. × 9 ft.	2.94	1.14	
Wood panel planer	34 in.	7.75	3.70	
Wood surface	24 in.	3.40	2.00	
POLISHING STANDS.				
Brown & Sharpe	No. 3	....	1.00	
Diamond	No. 5	....	1.19	
PUNCH PRESSES.				
Bliss	No. 3	2.59	1.26	
PROFILING MACHINES.				
Garvin	No. 1	....	0.50	
Pratt & Whitney	No. 6	....	0.40	
BAND SAW.				
Fay & Co	36-in. wheels	3.00	0.87	Used for pattern work.
CIRCULAR SAWS.				
Kimball Bros	9-in. blade	3.77	1.05	
Whitney	9-in. blade	3.75	1.04	
White	13-in. blade	5.82	1.21	
HACK SAW.				
....	12 in. to 14 in.	....	0.06	
SCREW MACHINES.				
Brown & Sharpe automatic	No. 1	....	0.60	
Pratt & Whitney automatic	No. 2	....	0.37	
Pratt & Whitney	No. 2	....	0.72	
Pratt & Whitney	No. 3	....	0.80	
Brown & Sharpe automatic	No. 3	....	0.80	
Pratt & Whitney automatic	No. 3-O	1.04	0.90	
Pratt & Whitney	No. 3-B	1.04	0.90	
Brown & Sharpe	No. 00	....	0.36	
Cleveland	7/8 in.	....	0.40	
Cleveland	2 in.	....	0.87	
Cleveland	2 3/4 in.	1.04	0.90	
Pratt & Whitney hand	No. 2	....	0.43	
Pratt & Whitney hand	No. 2 1/2	....	0.47	
Pratt & Whitney hand	No. 3	....	0.50	
SHAPERS.				
Lodge & Davis	14 in.	....	0.35	
Hendey	20 in.	....	0.50	
Hendey	24 in.	....	0.52 to 0.70	
Hendey	28 in.	....	0.52 to 0.70	
TAPPING MACHINE.				
Pratt & Whitney	No. 2	....	0.10	

TABLE 13.—POWER VALUES FOR MACHINE TOOLS IN GROUPS. *Continued.*

277. *Q.*—How are vertical drilling machines driven?

A.—In general these machines are arranged in groups. If motor-driven a variable-speed, direct-current type should be selected. The connection may be through a countershaft or to the machine direct.

278. *Q.*—How are radial drilling machines driven?

A.—See vertical drilling machines.

279. *Q.*—What is the horse-power required for machine tools arranged in groups?

A.—Table 13 from test made by L. P. Alford gives horse-power values for some 150, small and medium-sized machine tools for group driving. If only a few tools are grouped the values should be used as given in the table. If a large group is under consideration the total of the values taken from the table should be reduced by 20 per cent. This is because of departmental slips, that is, the occasional stoppage of machines for putting in or taking out work or other reasons.

280. *Q.*—What are the sizes of motors for engine lathes?

A.—These are given in Table 14.

Swing in inches	Horse-power for light duty	Horse-power for medium duty	Horse-power for heavy duty
14	2	3	5
16	3	5	5
18–20	3	5	7 1/2
22–24	5	7 1/2	10
27–30	7 1/2	10	15
36–48	7 1/2	10	20

TABLE 14.—SIZES OF MOTORS FOR ENGINE LATHES.

Size in inches	Horse-power for medium duty	Horse-power for heavy duty
24×24	5	7 1/2
30×30	7 1/2	....
36×36	10	....
42×42	....	25
48×48	15	....
56×56	15	30

TABLE 15.—SIZES OF MOTORS FOR PLANERS.

281. *Q.*—What are the sizes of motors for planers?
A.—These are given in Table 15.

282. *Q.*—What are the sizes of motors for shapers?
A.—These are given in Table 16.

Size in inches	Horse-power
14–20	3
24	5
26	7 1/2

TABLE 16.—SIZES OF MOTORS FOR SHAPERS.

283. *Q.*—What are the sizes of motors for crank slotters?
A.—These are given in Table 17.

Size in inches	Horse-power, light duty	Horse-power, medium duty
10	3	5
10–16	5	7 1/2
20	7 1/2	10
26–30	15	....

TABLE 17.—SIZES OF MOTORS FOR CRANK SLOTTERS.

284. *Q.*—What are the sizes of motors for millers?
A.—These are given in Table 18.

Table feed in inches	Cross feed in inches	Vertical feed in inches	Horse-power for medium duty
24	8	18	3
30	10	18	5–7 1/2
36	12	20	7 1/2–10
50	12	20	10–15

TABLE 18.—SIZES OF MOTORS FOR MILLERS.

285. *Q.*—What are the motor sizes for vertical millers?
A.—These are given in Table 19.

Table diameter in inches	Spindle diameter in inches	Horse-power
28	4	5
32	4	7 1/2
40	4 1/2	10
54	5	15
70	6	20

TABLE 19.—SIZES OF MOTORS FOR VERTICAL MILLERS.

286. *Q.*—What are the sizes of motors for vertical drilling machines?
A.—These are given in Table 20.

Size in inches	Horse-power
Friction	1/4
15	1/2
20–26	1
28–34	2
40–50	3

TABLE 20.—SIZES OF MOTORS FOR VERTICAL DRILLING MACHINES.

287. *Q.*—What are the size of motors for radial drilling machines?
A.—These are given in Table 21.

Length of arm in feet	Horse-power
4	3
5	5
6	5
10	7 1/2

TABLE 21.—SIZES OF MOTORS FOR RADIAL DRILLING MACHINES.

288. *Q.*—What are the sizes of motors for vertical boring mills?
A.—These are given in Table 22.

289. *Q.*—What are the sizes of motors for cylindrical grinders?
A.—These are given in Table 23.

Size in inches	Horse-power
24-30	5
36-42	7 1/2
60-90	10
100	15
Feet	
10	20
12	20
14	25
16	30

TABLE 22.—SIZES OF MOTORS FOR VERTICAL BORING MILLS.

Size in inches	Horse-power for medium duty	Horse-power for heavy duty
10×50	5	7 1/2
10×72	5	7 1/2
10×96	5	7 1/2
10×120	5	7 1/2
14×72	10	12
18×96	10	15
18×120	10	15
18×144	10	15
18×168	10	15

TABLE 23.—SIZES OF MOTORS FOR CYLINDRICAL GRINDERS.

290. *Q.*—What are the sizes of motors for cold saws?
A.—These are given in Table 24.

Diameter of saw in inches	Thickness of saw in inches	Horse-power
12	5/32	2
15	5/32	2
18	3/16	3
20	3/16	3
24	3/16	5
32	3/16	7 1/2
36	3/16	10

TABLE 24.—SIZES OF MOTORS FOR COLD SAWS.

291. *Q.*—What horse-power is required to remove 1 cu. in. of metal per minute on the lathe?

A.—For general average conditions the following values are true. It must be remembered, however, that considerable variation may occur when special cutting tools are used and special grades of metal handled.

Brass and similar alloys, 0.2 to 0.3.
Cast iron, 0.3 to 0.5.
Wrought iron, 0.6.
Mild steel (0.30 to 0.4 per cent. carbon), 0.6
Hard steel (0.5 per cent. carbon), 1 to 1.25.
Very hard tire steel, 1.5.

292. *Q.*—What is the average horse-power required to remove 1 cu. in. of metal per minute on the boring mill?

A.—See values given for the lathe above.

293. *Q.*—What is the average horse-power required to remove 1 cu. in. of metal per minute on the planer?

A.—See values for lathe given above.

294. *Q.*—What is the average horse-power required to remove 1 in. of metal per minute on the slotter and shaper?

A.—See values for the lathe given above.

295. *Q.*—What is the average horse-power required to remove 1 cu. in. of metal per minute on the drilling machine?

A.—Brass and similar alloys, 0.4 to 0.6.
Cast iron, 0.6 to 1.
Wrought iron, 1.2.
Mild steel (0.3 to 0.4 per cent. carbon), 1.2.
Hard steel (0.5 per cent. carbon), 2 to 2.5.
Very hard tire steel, 3.

296. *Q.*—What is the horse-power required to remove 1 cu. in. of metal per minute on the miller?

A.—Mild steel, 1 to 1.5.
Cast iron, 0.8 to 1.2.
Chrome nickel steel, 1.5 to 2.2.

The above values must be taken as representative only for the fact that the type of cutter, rigidity of the machine, area of surface worked upon, and physical characteristics of the work have influence upon the amount of metal that can be removed per horse-power. The tests for which the above figures were taken were all made with high-speed steel cutters mainly of the face milling type.

CHAPTER VIII

POWER TRANSMISSION

BELTS

297. *Q.*—What gives a belt its driving power?

A.—Friction between the surfaces in contact.

298. *Q.*—Upon what does the driving power of a belt depend?

A.—On the difference in the tension between the tight and slack sides.

299. *Q.*—What limits this unbalanced tension?

A.—If it becomes greater than the friction of the belt on the pulley, the belt will slip and prevent increase of driving force.

300. *Q.*—How is the capacity of a belt affected by its speed?

A.—It varies directly as the speed. A given belt will, within reasonable limits, transmit twice the horse-power if its speed is doubled.

301. *Q.*—What is the practical limit of belt speed?

A.—As a rule, they should not run over 5000 ft. per minute, the most economical speed being between 4000 and 4500.

302. *Q.*—How does the width of a belt offset its capacity?

A.—The capacity varies directly as the width. If a 2-in. belt will transmit 1 h.p., two such belts will transmit 2 h.p., and this is true whether they are run separately or joined into a 4-in. belt.

303. *Q.*—What other factor enters into the capacity of a belt?

A.—Its thickness. A double belt will transmit more power than a single, a three-ply more than a double.

304. *Q.*—How is the capacity of a belt estimated?

A.—It is assumed that a belt 1 in. in width will transmit 1 h.p. at the following speeds:

Single laced, 1000 ft. per min.
Single cemented, 800 ft. per min.
Double laced, 600 ft. per min.
Double cemented, 400 ft. per min.

Then as the power is directly as the width and speed we have

$$\frac{W \times S}{e} = \text{horse-power}$$

Where W = width in inches
S = feet per minute.
e = constant as above (1000 for single laced, etc.).

Rule.—Multiply the width of the belt in inches by it speed in feet per minute and divide by 1000 for single-laced belts, 800 for single cemented, 600 for double-laced, and 400 for double cemented.

Example.—How much power will a 10-in. double-laced belt running over a 5-ft. pulley which makes 215 revolutions per minute transmit?

A 5-ft. pulley at 215 revolutions per minute would have a speed of $5 \times 3.1416 \times 215 = 3{,}377.22$ ft. per minute.

This multiplied by the width, 10, and divided by the constant for a double-laced belt, 600, would give

$$\frac{3377.22 \times 10}{600} = 56.287 \text{ h.p.}$$

305. *Q.*—How could this be determined from the diameter?

A.—The operation followed above is

$$\frac{D \times 3.1416 \times W}{e}$$

If we divide 3.1416 by the constant we shall have simply to multiply the diameter by that quotient and by the width. For instance, with a single laced belt the constant is 1000, and

$$\frac{D \times 3.1416 \times W}{1000} = DW\ 0.0031416.$$

If instead of 1000 we used 1047 it would divide 3.1416 three times, and the formula would be:

$$D\ W\ 0.003 = \text{horse-power.}$$

By slight changes in the constants of the other belts we get,
For single laced, 0.003.
For single cemented, 0.004.
For doubled laced, 0.005.
For double cemented, 0.008.

Rule.—Multiply the diameter of the pulley in feet by the width of the belt in inches and by the above constant.

Both rules are approximations and one is probably as correct as the other.

306. *Q.*—Do these rules give the maximum driving power of the belts?

A.—No. They give the power which the belt ought to give when working under good average conditions, arc of contact, etc., without slippage, fatigue, or excessive wear.

307. *Q.*—What is meant by the "arc of contact"?

A.—The proportion of the total circumference of the pulley in contact with the belt.

308. *Q.*—What effect has the arc of contact on the amount of power which can be transmitted?

A.—The power varies directly with the arc of contact, and will be only one-half as great when the belt wraps one-quarter around the pulley as when it covers one-half of its circumference.

309. *Q.*—What rule is used for finding the width of belt required to transmit a given horse-power which takes account of the arc of contact?

A.—Samuel Webber, gives the following from his practice:

For single belts

$$W=\frac{\text{velocity}\times\text{contact}}{\text{h.p.}\times 5500}$$

For double belts

$$W=\frac{\text{velocity}\times\text{contact}}{\text{h.p.}\times 3660}$$

where the velocity is in feet per minute and the contact in feet of contact on the smaller pulley.

Rule.—Multiply the horse power by 5500 for single or 3660 for double belts and divide by the product of the velocity in feet per minute and the arc of contact on the smaller pulley in feet.

Example.—How large a double belt would be required to transmit 160 h.p. at 3200 ft. per minute with 7.5 ft. of contact on the smaller pulley?

$$W=\frac{160\times 3660}{3200\times 7.5}=24\text{ in.}$$

310. *Q.*—In what other way may the capacity of a belt be calculated?

A.—By the square feet of belt passing over the pulleys per minute.

311. *Q.*—How many square feet per minute are required per horse-power?

A.—A double-laced belt will transmit a horse-power for each inch in width at 600 ft. per minute belt velocity. This would be a strip 1 in. wide and 600 ft. long, or 50 sq. ft., passing over the pulleys per minute per horse-power. Figuring in this way we get for the varieties of belt given:

Single laced	83 1/3 sq. ft. per minute.
Single cemented	66 2/3 sq. ft. per minute.
Double laced	50 sq. ft. per minute.
Double cemented	33 1/3 sq. ft. per minute.

312. *Q.*—What can be said of belt formulæ in general?

A.—They are empirical, expressing the results of practice rather than a general law. The most that they can do is to give a general idea of what is required under average conditions. When the distance between shaft centers is small, with pulleys of widely varying diameter, giving a small arc of contact, liberal allowances must be made.

313. *Q.*—How much wider should the pulley be than the belt?

A.—At least 20 per cent. wider, or 1 1/5 times as wide.

314. *Q.*—How much will a leather belt stretch?

A.—About 6 per cent. of its length.

315. *Q.*—Which is preferable, a narrow and thick belt, or a wide and thin one?

A.—The narrow and thick.

316. *Q.*—Give a rule of thumb for locating a jack-shaft to secure good belting conditions.

A.—Make the distance between centers not less than 2 1/2 times the diameter of the large pulley. The small pulley should be at least one-third the diameter of the large to secure a proper arc of contact.

317. *Q.*—Where should the slack side of the belt be run?

A.—On the top, so that the slack may hang down and bring more of the belt into contact with the pulleys.

318. *Q.*—What are the conditions necessary to the successful running of a quarter-turn belt?

A.—The distance *A B*, between the near faces of the pulleys, Fig. 24, must not be less than 4 times the width of the belt. The pulleys must be placed so that the belt will lead off from the face of one on to the center of the face of the other, *i.e.*, so that a plane C D, cutting the center of one pulley, will be tangent to the other.

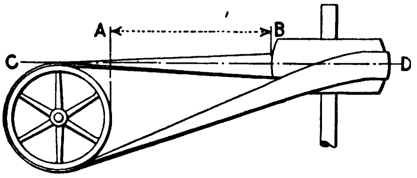


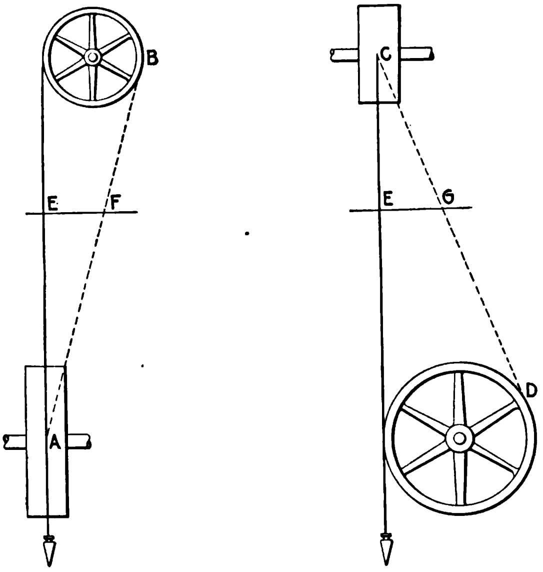
FIG. 24. HOW TO RUN A QUARTER TURN BELT.

319. *Q.*—How should pulleys be set for a quarter-turn belt driving between two stories?

A.—Drop a plumb-line from the center of the face of the upper pulley, bore a hole in the floor so that the line can pass through, and locate the lower pulley so that the plumb-line will cut it centrally, as in Fig. 25. The line should just touch the edge of the lower pulley, as in Fig. 26. If it does not, move the upper pulley along the shaft until it will.

320. *Q.*—How should holes in a floor for a belt be laid out?

A.—Lay out the transmission to scale, as in Fig. 25. The line representing the plumb-line will be the center of the vertical belt. Draw the diagonal lines A B and C D. Draw the pulleys in plan to the same scale, as in Fig. 27. The point of intersection, *x*, of the two pulleys marks on the plan the position of the plumb-line. Lay off the distance *x f* on the plan equal to the distance E F in Fig. 25, and the distance *x g* on the plan equal to E G in Fig. 26.



FIGS. 25 AND 26. QUARTER TURN BELT DRIVING BETWEEN TWO STORIES.

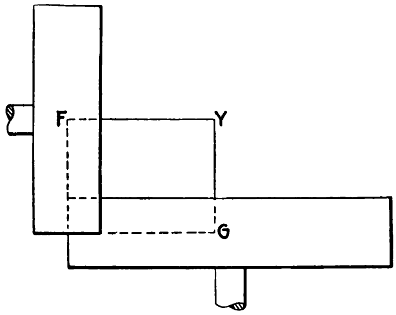


FIG. 27. PLAN OF PULLEYS.

Complete the parallelogram as in Fig. 27, and the point Y will mark the center line of the returning side of the belt. Bore a hole at this point and pass a piece of tape or narrow belt around the pulleys, which will indicate the obliquity of the holes. These positions are those the belt will assume when tight and at rest. Allowance must be made for the sag movement of the belt when at work.

321. *Q.*—How else may power be transmitted around a corner?

A.—It can be done with a tight and a loose pulley on each shaft, as in Fig. 28. The loose pulley will run in the opposite direction from the tight, and the shaft may be driven in either direction by using the corresponding pulley as the tight one.

322. *Q.*—How should a belt be laced?

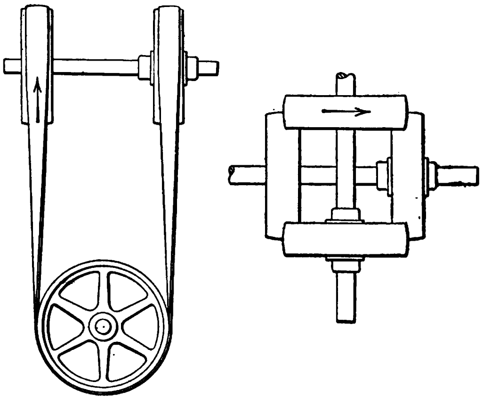


FIG. 28. ANOTHER METHOD OF DRIVING AROUND A CORNER.

A.—There are various methods of lacing, each of which has its advocates and some of which have special advantages for particular work. Several of these methods are shown in Fig. 29.

The following general directions apply to all but the wire laced:

Have the first row of holes at least 7/8 in. from the end of the belt. Have the second row at least 1 in. from the first row. Have the end holes at least 3/4 in. from the edge of the belt.

For large belts increase these distances somewhat. Space the holes equally between the end ones located as above so that the laces will be from 1/2 in. to 1 in. apart, according to the width of the belt. The hinge-joint shown in the lower left of Fig. 29 is specially adapted to fast running belts and belts passing over small pulleys where flexibility is a specially desirable feature.

323. *Q.*—How should a belt be spliced?

A.—Cut the belt as shown in Figs. 30, 31, or 32. The V-splice should be used on triple and quadruple belts and when idler pulleys are used. The step splice is especially for rubber belts. For double belting, rubber or leather, for all belts up to 10 in. wide, make the splice 10 in. long. For

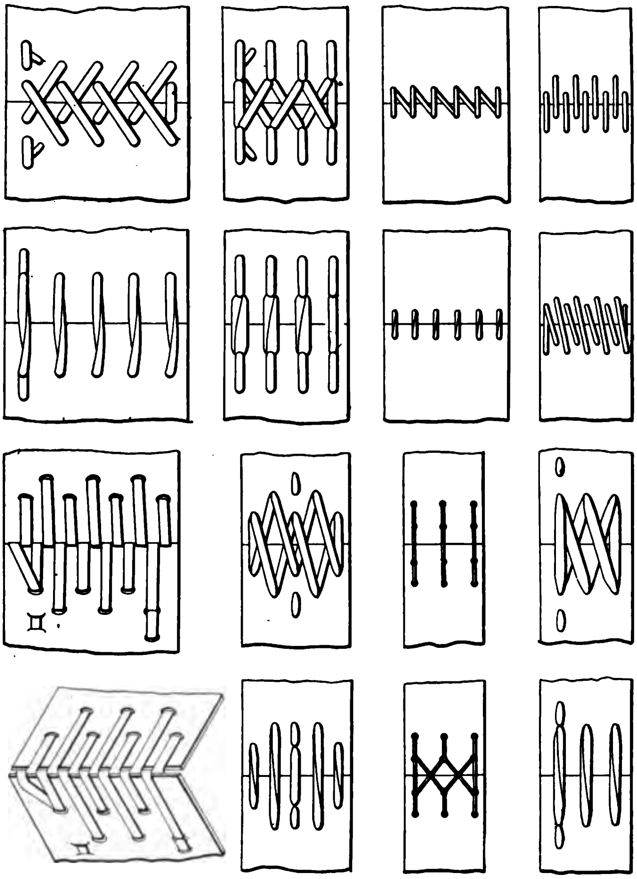
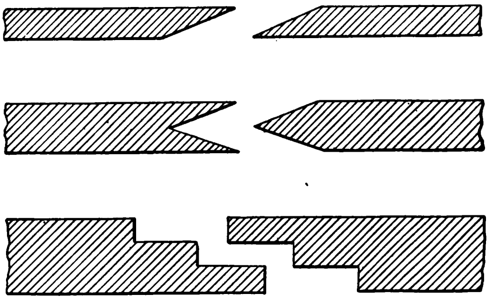


FIG. 29. VARIOUS METHODS OF LACING BELTS.



FIGS. 30, 31, 32. THREE METHODS OF SPLICING BELTS.

10- to 18-in. belts make the splice as long as the belt is wide; 18 in. being the longest splice required for a double belt.

324. *Q.*—How should rubber belts be joined?

A.—Coat it with uncured rubber in solution and vulcanize it after it is in place by means of steam-heated clamps.

325. *Q.*—What are the velocities in feet per minute that different sizes of good manila rope should run to transmit 1 h.p.?

A.—For transmitting 1 h.p. the ropes should run at the speeds given in Table 25.

Diameter of rope, inches	Speed per minute, feet
1/2	1034
5/8	652
3/4	454
7/8	333
1	260
1 1/4	164
1 1/2	114
1 3/4	83
2	73

TABLE 25—SPEEDS OF MANILA ROPE FOR TRANSMITTING 1 H.P.

The basis for this table is the assumption that a rope 1 in. diameter should have a working strain of 200 lb. at all speeds. This is about one-twentieth of the strength of the splice. This large margin is to enable the rope to perform a large amount of useful work before it is so weakened by wear that it is necessary to be renewed. For satisfactory results the diameter of the pulleys should not be less than 40 times the diameter of the rope, and as much larger as it is possible to make them. The angle of the sides of the grooves in which the rope runs varies, with different engineers, from 45 to 60 deg. It is very important that the sides of these grooves should be carefully polished.

326. *Q.*—What size of wire rope would be equivalent to a 2-in. hemp rope?

A.—A wire rope 1 in. in circumference will be equivalent to a hemp rope 2 in. in circumference. The breaking load of each is about 2240 lb.

PULLEYS

327. *Q.*—What is the relation between speeds and diameters of driving and driven pulleys?

A.—If there is no slippage the speeds will be inversely as the diameters of the pulleys. If the driven pulley is one-half the diameter of the driver its shaft will make twice the number of revolutions of the driving shaft. If the driven is twice the size of the driver its shaft will make one-half the number of revolutions of the driver, and so on for any other proportion.

Let D = diameter of driving pulley,
d = diameter of driven pulley,
R = revolutions per minute driving shaft,
r = revolutions per minute driven shaft,
then $D : d :: r : R$

from which proportion any of the factors can be found by the rule of three.

328. *Q.*—How is the size found for a driven pulley required with a given driver to produce a given number of revolutions of the driven shaft?

A.—To find the size of driven pulley from the above proportion:

$$\frac{D\,R}{r} = d.$$

Multiply the diameter of the driving pulley by the number of revolutions it makes per minute and divide by the speed of the driven shaft. The quotient will be the diameter of driven pulley required.

Example.—An engine having a 12-ft. flywheel is run at 95 r.p.m. What size pulley must be used on the jackshaft in order that it may run 120 r.p.m.?

$$\frac{12 \times 95}{120} = 9.5 \text{ ft.}$$

It is frequently more convenient to use the diameter of the pulleys in inches. It makes no difference in the calculation, but the diameters of *both* pulleys must be taken in the same units of measurements. If one is given in inches reduce the other to inches.

329. *Q.*—How is the size found for a driving pulley required to give a required speed to a driven shaft?

A.—To find the size of driving pulley required.

$$\frac{dr}{R} = D.$$

Multiply the diameter and speed of the driven together and divide by the speed of the driver. The quotient will be the diameter of the driver.

Example.—On a shaft which is to run 320 r.p.m. there is a 3-ft. pulley. The driving shaft runs 180 r.p.m. What must be the diameter of the driving pulley?

$$\frac{dr}{R} = \frac{36 \times 320}{180} = 64 \text{ ins.}$$

330. *Q.*—How is the speed of one shaft found when the diameter of pulleys and speed of the other shaft is given?

$$\frac{DR}{d}=r \text{ or } \frac{dr}{D}=R.$$

Multiply the diameter of the pulley whose speed is given by the speed, and divide by the diameter of the other pulley.

Example.—A pulley 28 in. in diameter and running at 280 r.p.m. is belted to a 34-in. pulley on another shaft. How fast will the latter shaft run?

$$\frac{DR}{d}=\frac{28\times 280}{34}=230.+ \text{ r.p.m.}$$

331. *Q.*—Suppose a driving shaft runs 110 revolutions and the driven shaft must run 165. How are the proper sizes of pulleys found?

A.—The pulleys must be to each other inversely as the speeds.

$$\frac{R}{r}=\frac{d}{D} \text{ or } \frac{110}{165}=\frac{2}{3}.$$

The pulleys must be to each other as 2 is to 3, *i.e.*, the driven must be 2/3 the diameter of the driver. We can fulfill this condition by making the driver pulley 6 in. and the driver, or by making the driver 30 ft. and the driven 20. The size of the pulleys will then have to be controlled by practical considerations. In the first place, there is a limit to the size of pulley that can be used on a line of shafting, set by the distance of the floor below or the ceiling above. Suppose the largest pulley that can be conveniently used on the driving shaft is 3 ft.; obviously we cannot use above

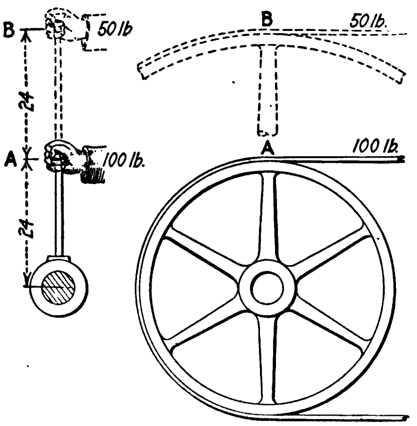


FIG. 33. INFLUENCE OF LEVERAGE IN PULLEY TRANSMISSION.

2 ft. on the driven. When the size of pulley most practicable for one of the shafts has been determined, the size of the other will be obtainable by the above rules.

332. *Q.*—Does the amount of power to be transmitted have any bearing upon the subject?

A.—It does. If in Fig. 33 it takes 100 lb. pull at *A* to turn the shaft, it could be moved with 50 lb. by placing the pull at *B*, twice as far out upon the lever. A pulley is a continuous lever, and it will be readily seen that 50 lb. pull on the belt at *B*, Fig. 33, will move the shaft against as much resistance as 100 lb. at *A*. The hand at *B* would have to move through twice the space to turn the shaft a given number of degrees, as would the one at *A;* and the belt at *B* would have to run twice as swiftly to give the shaft the same number of revolutions per minute as would one on a pulley of half the diameter, as at *A*. As the strain which can be put on an inch width of belt is limited we must have twice as wide a belt to transmit the same power from the small pulley. It is therefore an advantage to have the pulleys as large as posssible, or in other words to have the belts travel as fast as possible.

333. *Q.*—What is the coefficient of friction between a leather belt and a cast-iron pulley, bolt belt and pulley surface being in average condition?

A.—About 0.28, as determined by M. Morin.

334. *Q.*—What is the coefficient of friction of leather belts in ordinary condition on wooden pulleys?

A.—About 0.47, by the same authority.

SHAFTING

335. *Q.*—How do you determine the size of shaft necessary to transmit a given horse-power?

A.—D. K. Clark gives the following formula:

Wrought Iron $$\frac{d^3 s}{190}=\text{h. p.}\qquad \sqrt[3]{\frac{190\ \text{h.p.}}{\text{s}}}=d$$

Steel $$\frac{d^3 s}{92}=\text{h. p.}\qquad \sqrt[3]{\frac{92\ \text{h.p.}}{\text{s}}}=d$$

Rules.—To find the maximum horse-power of a shaft within good working limits, multiply the cube of the diameter in inches by the speed in turns per minute and divide by 190 for wrought iron or by 92 for steel. The quotient is the horse-power.

To find the diameter of a shaft capable within good working limits of transmitting a given horse-power:

Multiply the horse-power by 190 for wrought iron or by 92 for steel, and divide by the speed in turns per minute. The cubic root of the quotient is the diameter in inches.

To find the speed required for transmitting a given horse-power within good working limits:

Multiply the horse-power by 190 for wrought iron or by 92 for steel and divide the product by the cube of the diameter in inches. The quotient is the speed in turns per minute.

336. *Q.*—What should be the length between hangers for solid shafting?

A.—From 6 to 8 ft. when lightly weighted.

337. *Q.*—What precautions should be observed in regard to location of pulleys?

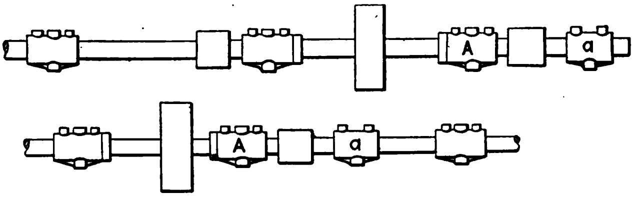


FIG. 34. LOCATION OF PULLEYS ON SHAFTING.

A.—Locate pulleys near hangers where possible so that the shaft may be sprung as little as possible by the pull of the belt. Where the belt is large or the duty severe it is well to put a hanger on both sides of the pulley which receives the power. At all events that length of shafting upon which the power is received should have at least two hangers, as in Fig. 34, where it will be seen that if in either cases the hanger *A* was located at *a* the coupling would be subjected to a sidewise strain.

338. *Q.*—How do the standard sizes of shafting vary?

A.—The sizes advance by quarter inches up to 4 in., then by half inches, but the shaft is always one-sixteenth less than the quarter, half, or even inch. A 2-in. bar when turned and finished becomes a 1 15/16 shaft. The size below it is a 1 11/16 turned from a 1 3/4-in. bar, and the next size above is 2 3/16 turned from a 2 1/4-in. bar.

CHAPTER IX

SHOP AND MACHINE SAFEGUARDS

339. *Q.*—What are some of the safeguards that should be in every shop, but are frequently missing?

A.—Guard rails for open stairways; "dead lines" on the shop floors, outside of which material must not be laid to cause bruises or falls; automatic gates for elevator openings; gates or guard rails for all open outside doors above the first floor; wire nets over the tops of elevators as a protection from small parts that might accidentally fall down the shaft; boxed-in floor belts; guarded screw machine stock; cans for oily waste or rags; splash guards on machines to keep oil or lubricants off the floor which they render slippery or inflammable; but above all, ample means of escape in case of sudden, flashing fire.

340. *Q.*—How should a workman in the average machine shop be dressed?

A.—He should wear clothing with no loose or flapping parts to catch in gears, belts or pulleys, and his sleeves should be close fitting, preferably buttoned at the wrist, or still better in many cases, cut short at the shoulder or elbow. This last is especially true for operators of batteries of automatic machines where the parts are subject to sudden movement. Loose ties should not be worn.

341. *Q.*—What is one of the most dangerous features of the average machine shop?

A.—The projecting setscrew, which is dangerous, no matter where it is used on machinery in motion. Even a plain shaft will sometimes grip clothing so firmly that the unfortunate wearer is caught and revolved with it. A projecting screw should never be used on any kind of machinery, unless suitably guarded. The headless setscrew, which does not project beyond the surface, is the safest, and should be insisted upon.

342. *Q.*—What are the principal danger points on a lathe?

A.—The change gears, if they are on the end, as in the older types of lathes; the back gears, and projecting setscrews on lathe dogs.

343. *Q.*—How may these be made safe?

A.—By having adjustable covers over the change gears; permanent guards over the back gears and by the use of dogs that either use headless setscrews, or are made so as to guard the head of the screw used.

344. *Q.*—Should wire or metal be used to lace the cone belt of a lathe?

A.—No, this belt should be either cemented or laced with rawhide, so that when the operator throws the belt from one step to another, his hands are not liable to be torn. Where wire or metal fastening is used, projecting points are also liable to catch sleeves or other parts of the clothing.

345. *Q.*—What are the danger points of the common type of vertical drilling machine, and how may they be guarded?

A.—Belts, back gears and spindle gears. The belts should be cemented if possible, and guards placed so as to prevent operators or work getting against them. The back gears should be covered, and where the pulleys or gears are close to the floor it is best to have heavy screens placed around them. In the case of small drilling machines operated by girls, guards in front of the spindles are also necessary to prevent the possibility of their hair catching.

346. *Q.*—In setting up a shaper, what one thing must be guarded against more than any other?

A.—To so set the machine that the ram, at the extreme backward stroke, does not come within at least 1 ft. and preferably 2 ft. of a wall or post, and so avoid the possibility of crushing some one passing between.

347. *Q.*—Should this same precaution be observed in the placing of a planer?

A.—Yes.

348. *Q.*—What is one great source of accidents in the operating of a miller?

A.—Probably the attempts of careless operators to brush chips away from the cutters with the fingers. If necessary to remove chips while the cutters are in motion, a brush should be provided, or better still, an air blast.

349. *Q.*—How may milling cutters be guarded?

A.—By a semicircular steel guard made in halves, pivoted on the overarm and surrounding the cutter. Such a guard is adjustable for various-sized cutters.

350. *Q.*—What one class of machines are especially dangerous when unguarded?

A.—Punch presses.

351. *Q.*—How can these be guarded?

A.—Besides guards for any exposed gears and flywheels, there are a number of automatic guards on the market, intended to keep the operator's fingers and hands out from under the punches. Some of these provide a gate in front, which is so attached to the tripping mechanism that it is impossible to trip the press unless the operator's hands are out of the way, so that the guard can move into position.

A very satisfactory method is to use a device which requires both hands to trip the press.

352. *Q.*—How are operators injured by grinding wheels?

A.—By the wheel breaking and the pieces being thrown with terrific force; by particles of the abrasive or the material being ground getting into the eyes; and by the finer particles being inhaled and settling in the lungs.

353. *Q.*—How can injuries of the first kind be prevented?

A.—Modern grinding wheels almost never burst from centrifugal force. When wheels burst it is either from mechanical injury such as from the wheel being accidently dropped or from work being jammed between the wheel and the grinding rest. Wheels should never be forced on the spindle but should have about 0.005 in. play and be held by relieved flanges at least one-third the diameter of the wheel. Fig. 35 shows the right and wrong method of mounting wheels. A good protection hood should be used in all cases, so as to prevent the broken particles of the wheel from flying even if it should be cracked.

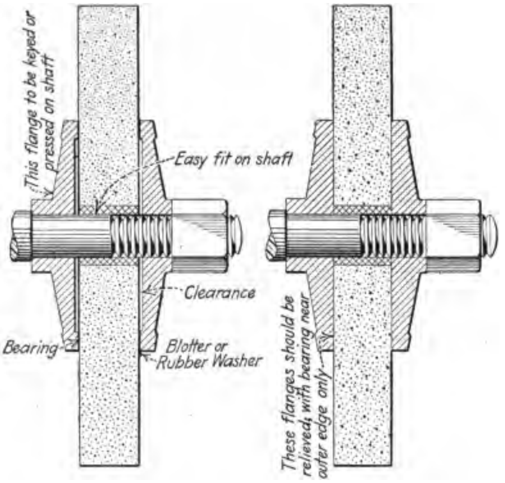

This flange to be keyed or pressed on shaft
Easy fit on shaft
Clearance
Bearing
Blotter or Rubber Washer
These flanges should be relieved, with bearing near outer edge only

FIG. 35. RIGHT AND WRONG METHOD OF MOUNTING GRINDING WHEELS.

354. *Q.*—How can the eyes be protected?

A.—Either by the operator wearing goggles or the use of a grinding shield, preferably of glass, so that the operator can see exactly what he is doing. Details of one of these shields are shown in Fig. 36. A spark brush, which is simply a leather flap extending down over the wheel, also tends to prevent fine particles flying into the eye.

355. *Q.*—How is the dust prevented from getting into the lungs?

A.—In some cases the operator wears a respirator over the mouth and nose. This, however, is not usually necessary if the grinding wheel hood is connected to a proper exhaust system so that all the flying particles are drawn away from the wheel and the operator. All modern grinding, polishing and buffing rooms are equipped in this way, and it should be made compulsory in all cases.

356. *Q.*—Is there a practical method of preventing wheels being run at too high speed?

A.—A very simple plan is to have a rod or projection of some kind extending from the body of the machine in such a way that it is impossible to put a wheel on the spindle, which is larger than a predetermined size. This pin is located so that the speed of any wheel which can be put on the spindle must be within the safe limit considering the speed of the grinding spindle.

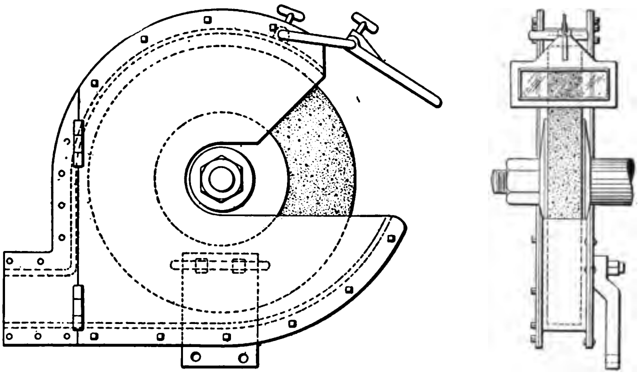


FIG. 36. SHIELD FOR GRINDING WHEEL.

357. *Q.*—Are poorly lighted shops conducive to accidents?

A.—Yes. Lack of good light not only often prevents a workman seeing a dangerous object, but it has a tendency to confuse a man, as it tires his eyes and makes him more liable to mistakes.

358. *Q.*—What is a good way to improve the lighting of a poorly designed shop?

A.—By whitewashing or painting the interior white, and keeping the windows as clean as possible. Where artificial lighting is necessary, the lights should be so placed as to throw the light on the work and not into the operator's eyes.

359. *Q.*—How can slipping be prevented around wood-working machines?

A.—By covering the foot space with a rubber mat, or even prepared gravel roofing.

360. *Q.*—How are band saws guarded?

A.—By enclosing the wheels and saw except for the small space where the cutting is done.

361. *Q.*—How are circular saws guarded?

A.—By a cover over the saw that is pushed away when sawing is being done.

362. *Q.*—How are jointers safeguarded?

A.—By using a circular-bodied cutter head from which the blades only project enough to give the cut. This type should be used for all cutter heads.

363. *Q.*—How should openings in shop floors, as flywheel pits, be guarded?

A.—With a substantial pipe rail and a toe board on the floor.

364. *Q.*—How should a shop elevator be guarded?

A.—With substantial gates at the landings, and a heavy wire netting over the top.

365. *Q.*—How should motors-tarting switches be safeguarded?

A.—By a chain or lock that will lock the switch handle when a man is working on the shafting.

366. *Q.*—How can sandblasting be made harmless work?

A.—By having the men wear a compressed air-helmet on large work, or putting small work in a separate room into which the operator puts his arms through holes covered with canvas flaps, and watches the work through a window.

367. *Q.*—What are the dangerous wood-working tools?

A.—The band saw, circular saw and jointer or buzz planer. In fact, all machines using a rapidly revolving cutter head.

368. *Q.*—What is a good way to arrange the washrooms to prevent the communication of disease?

A.—Either have individual wash bowls, or individual streams of water running into a sink or drain, the users to have their own soap and towels in either case.

369. *Q.*—Is it a good plan to let the employees hang their clothes together?

A.—No. Individual metal lockers are best. These should be so made as to provide ventilation yet be tight enough to prevent as much as possible the free passage of vermin from one to the other. To do this, of course, insures the clothing of one not coming in contact with that of another.

370. *Q.*—How should the drinking facilities be made to insure safe sanitary conditions?

A.—Either use individual cups or else provide bubbling fountains of some kind.

371. *Q.*—What other great source of contagion is common?

A.—Filthy, ill-ventilated closets. These should be kept well aired by providing sufficient ventilation, and should be frequently cleansed with plenty of soap and water, and well sprinkled with disinfectant.

CHAPTER X

PATTERNMAKING AND WOODWORKING

372. *Q.*—What is the wood most commonly used for patterns?

A.—White pine, which should be air seasoned, straight grained and free from knots.

373. *Q.*—Are any other woods used?

A.—Yes, mahogany, cherry, beech and maple.

374. *Q.*—What is the best way to season pattern lumber?

A.—Stand it in a dry place in such a way that air can circulate on all sides of it.

375. *Q.*—How is the tendency to warp overcome?

A.—By gluing several pieces together in such a way that the warping of the various pieces will tend to neutralize each other.

376. *Q.*—In arms for pulleys where stiff, thin pieces are required, how are they made?

A.—By gluing *three or more* pieces at right angles to each other.

377. *Q.*—Why won't two pieces do?

A.—Because if only two thin pieces are used the work will warp.

378. *Q.*—Should a wide thin piece of a single thickness be required, how should it be made?

A.—The board from which it is to be made should be ripped into narrow strips and then glued together with each alternate strip reversed, which neutralizes the warping tendency.

379. *Q.*—Where it is necessary to join the ends of parts of a pattern, what is the best way?

A.—There are a number of methods which may be used according to requirements, some of which are shown in Fig. 37.

380. *Q.*—Should nails ever be used to hold patterns together?

A.—Never, except where they can be so placed as to be entirely removed from all danger of contact with the tools used in turning and shaping the pattern, and when so employed should be used in conjunction with glue. The only advantage is that they take the place of hand screws or clamps while the glue is drying. As a rule their use is unsatisfactory.

381. *Q.*—What kind of glue is most suitable for pattern work?

A.—Only the best quality of cabinetmaker's glue or better still the best quality of white glue should be used. The white glue comes in two forms: clear and opaque. The first is glue without any foreign substance and the second contains whiting or other mineral and looks much whiter. The addition does not injure the adhesive qualities of the latter, but it sets more readily and dries quicker, and for this reason cannot be used on large surfaces, but for small or medium-sized work it is preferable.

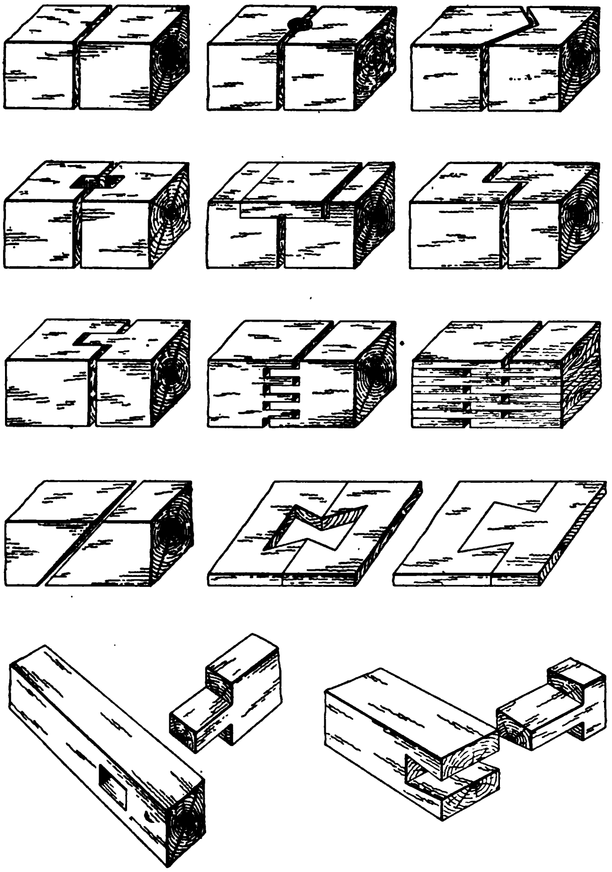


FIG. 37. VARIOUS METHODS OF JOINING THE ENDS OF PARTS OF A PATTERN.

382. *Q.*—Should a large amount of glue be made up at a time?

A.—No. Good glue will keep in a dry room indefinitely, but when cooked in a glue pot it deteriorates rapidly, and each successive reheating and boiling lessens its adhesive qualities. Thus, it should be used as fresh as possible, and no more made up than will last for two or three days at most.

383. *Q.*—How should the glue be made?

A.—No hard and fast rule can be given, but generally pack the glue firmly in the pot and add enough *cold* water to cover it. Next fill the outside kettle with cold water and boil until thoroughly cooked, so that the glue will run freely from the brush or paldde without forming bunches or clots. If the glue is too thick, no amount of pressure will bring the surfaces to be glued into close contact, on the other hand glue too thin will make the joint weak. If the glue needs thinning, do so with hot water from the outside pot, but never use hot water to dissolve the glue in the first place, as it makes it stringy.

384. *Q.*—Why are patterns varnished?

A.—To fill the pores of the wood and make it more or less impervious to moisture. It also gives a smooth surface which keeps the sand from having such a tendency to cling to it.

385. *Q.*—What is generally used for this purpose?

A.—Shellac, to which is added lampblack, yellow ochre or other substance to give the color desired.

386. *Q.*—Are the pattern and core print made the same color?

A.—The common practice is to make the pattern black and the core print yellow or orange, so that the molder can distinguish them at a glance. This varies, however, in some shops where patterns for various metals are made.

387. *Q.*—What are core prints?

A.—Projections on a pattern intended to form cavities in the mold, in which the cores may be set in their correct relation to the rest of the mold.

388. *Q.*—What are fillets?

A.—Strips made of leather or wood used to round out the corners of a pattern. Beeswax is sometimes used for this purpose, though not as often as formerly, owing to the cheapness and convenience of the leather fillets.

389. *Q.*—What is meant by draft in a pattern?

A.—Draft is the taper or bevel made on parts of a pattern, so that it may be easily drawn from the sand.

390. *Q.*—What is shrinkage?

A.—It is the amount the patternmaker must allow for the shrinking of the metal to be cast as it cools.

391. *Q.*—What amount of shrinkage is allowed for different metals?

A.—For all ordinary purposes, 1/8 in. per foot is allowed for cast iron; 3/16 in. for brass; 5/16 in. for zinc; 1/4 to 5/16 in. for lead; 7/32 in. for copper; 9/32 in. for tin; 1/8 in. for silver; 1/4 in. for aluminum and 3/16 to 3/8 in. for steel.

392. *Q.*—What is a shrinkage rule?

A.—It is a rule, usually made of a single piece of boxwood or beech, which is made enough longer than a regular rule to allow for the shrinking of the metal to be cast from the pattern. That is, for the making of a pattern for cast iron, the rule used is graduated exactly like the common rule, but is 1/8 in. longer to the foot. This allows the patternmaker to measure all parts direct, without any calculation, and when finished, the pattern will be large enough in all parts to allow for the shrinking of the iron when it cools.

393. *Q.*—How may the weight of a casting be calculated from a pattern?

A.—An approximate estimate may be obtained from Table 26, though varying conditions will make the results differ.

A pattern weighing 1 pound, less weight of core prints, made of:	Cast iron	Brass	Copper	Bronze	Bell metal	Zinc	Steel	Lead
White pine	16	15.8	16.7	16.3	17.1	13.5	17.3	25
Oak	9	10.1	10.4	10.3	10.9	8.6	......	......
Beech	9.7	10.9	11.4	11.3	11.9	9.1	......	......
Linden	13.4	15.1	16.7	15.5	16.3	12.9	......	......
Pear	10.2	11.5	11.9	11.8	12.4	9.8	......	......
Birch	10.6	11.9	12.3	12.2	12.9	10.2	......	......
Alder	12.8	14.3	14.9	14.7	15.5	12.2	......	......
Mahogany	11.7	13.2	13.7	13.5	14.2	11.2	......	......
Brass	0.85	0.95	0.99	0.98	1.0	0.81	......	......

TABLE 26.—CASTING WEIGHTS CALCULATED FROM PATTERNS.

394. *Q.*—What kinds of saws are used for woodworking?

A.—Rip and crosscut.

395. *Q.*—What is a rip saw?

A.—It is one used for cutting *with* the grain. In Fig. 38 is shown a rip saw with five and one-half points to the inch, which will work well in soft wood. For hard wood, six teeth should be used. The teeth on rip saws should be filed with all the bevel on the back of the tooth as shown at *A*, the front of the tooth being straight up and down, as shown at *B*. The position of the line *CD*, whether straight or slanting, is called the hook or pitch of the tooth. A saw of this kind should be filed straight across. Little set is needed, but

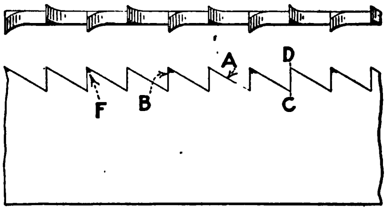


FIG. 38. RIP SAW.

what there is should be made by bending the points of the teeth only as shown at *F*. In no case should the set exceed half the depth of the tooth.

396. *Q*.—What is a crosscut saw?

A.—As its name indicates, it is used for sawing crosswise of the grain and should be filed as shown in Fig. 39, the front of the tooth being at an angle of about 60 deg.; thirteen and one-half teeth to the inch, which makes a good all-round saw for ordinary wood.

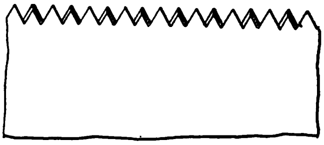


FIG. 39. CROSSCUT SAW PROPERLY FILED.

397. *Q*.—What is meant by the fleam of a saw?

A.—It is the bevel which is filed on the tooth.

398. *Q*.—In filing a crosscut saw what is the best way to proceed?

A.—With the saw held in a saw vise, and the file held at about 45 deg. to the side of the saw lengthwise of the blade, as shown in Fig. 40. Begin at the heel and file each alternate tooth to the point. Then file the opposite side the same way. Some filers object to this method, as they say it leaves a feather edge on the teeth, but the first thrust of the saw through wood removes this, while if the saw is filed from the point to the heel, the filing is *against* the edge, not only making the saw vibrate and chatter, but injuring the file.

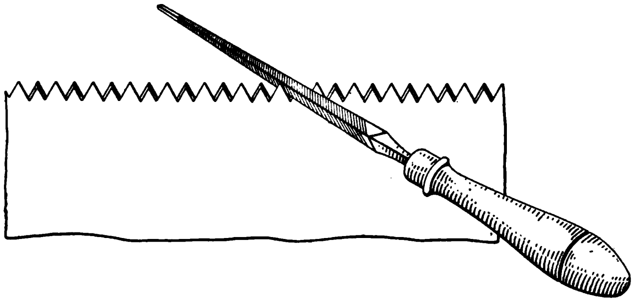


FIG. 40. HOW TO FILE A CROSSCUT SAW.

399. *Q*.—What is a back saw?

A.—One with a very thin blade, usually from 8 to 14 in. in length, with a rib along the back to stiffen it. It is used for light or fine work, and for fitting and dovetailing.

400. *Q.*—How many types of back saws are there?

A.—Two as in other classes—crosscutting and ripping, the latter being used to cut tenons, dovetails and the like.

401. *Q.*—What is a compass saw?

A.—It is a saw with a long tapering blade, shown in Fig. 41, with teeth filed so as to make it a sort of combination rip and crosscut, and is used for cutting out curves or circles, it being ground thin on the back so as to turn easily.

402. *Q.*—What are the more common types of planes used by patternmakers?

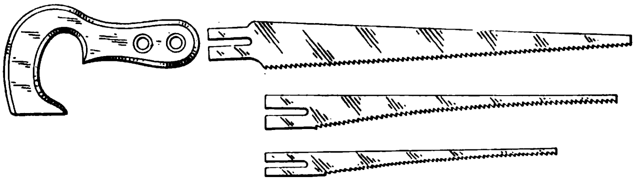


FIG. 41. COMPASS SAW.

A.—These are shown in Fig. 42. The jointer plane *A* is used to smooth up large surfaces, or long glue joints; the jack plane *B*, to plane when the lumber has been first roughly planed in the mill; the smooth plane and the block plane *D*, for planing ends; the scrub plane *E*, to rough down rough pieces for the finishing plane; the circular plane *F*, to plane arcs; the rabbet plane *G*, to work out square angles and corners; *H* is a round plane; *I*, a hollow plane; *J*, a core-box plane; and *K*, a router plane.

403. *Q.*—What is the core-box plane used for?

A.—For making semicircular core-boxes, the principle being that illustrated in Fig. 43. The objection is sometimes made that this plane wears down the corners when working soft wood, but this can be remedied by tacking thin strips of hard wood to the edges and cutting out the hollow closely to size, then removing the strips to finish.

404. *Q.*—What is the router plane used for?

A.—It is used for smoothing out sunk panels, letting in rapping plates, and for various depressions below the general surface of the pattern. It will plane the bottoms of recesses to a uniform depth from the surface of the work and will reach places otherwise only accessible to the paring chisel.

405. *Q.*—How should the blade of a plane be sharpened?

A.—All grinding or whetting must always be done on the bevel side, the upper side being kept as flat and smooth as possible. All plane irons used for flat work should be ground rounding to the extent of a thin shaving. This rounding should be the true arc of a circle throughout the entire length of the cutting edge, and not simply a rounding off of the corners. The

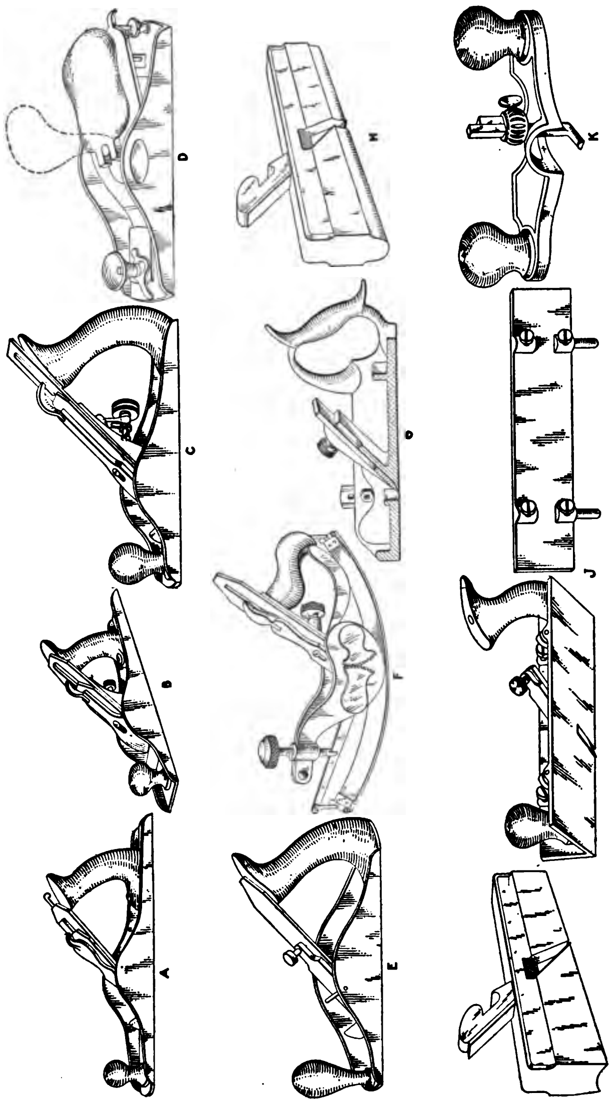


FIG. 42.—Common Types of Planes Used by Patternmakers.

object is to prevent the plowing out of a wide groove in the work, and it greatly assists in planing the piece to right angles with the edge.

406. *Q.*—What chisels are commonly used?

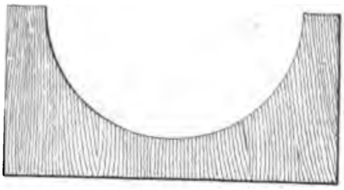


FIG. 43. CORE BOX PLANE WORK.

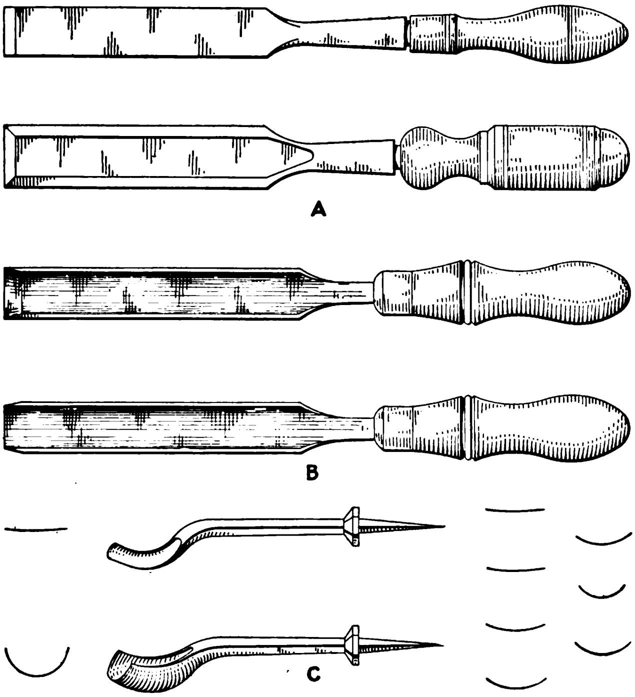


FIG. 44. FORMS OF CHISELS USED BY PATTERNMAKERS.

A.—These are shown in Fig. 44 paring chisels *A;* paring gouges *B;* front bent gouges *C.* All these chisels are made in sizes and shapes to suit the work in hand.

407. *Q.*—What other hand tools are used by the patternmaker?

A.—Hammers, mallets, squares, dividers, trammels, marking gages, calipers, screw drivers, boring bits, side cutting pliers, cabinet files, rasps and clamps. Some patternmakers make use of a number of other more or less special tools.

408. *Q.*—What machines should a pattern shop have?

A.—It all depends on the class and amount of work turned out; however, for a small shop doing a fair amount of work, the following machines are very convenient, not to say a necessity: turning lathe, with a good set of turning tools; band saw, circular saw bench, and a trimmer.

CHAPTER XI

FOUNDRY WORK

409. *Q.*—What tools are ordinarily used by a molder?

A.—Those shown in Fig. 45 represent those in common use. (Flat blade shovel, sieve, rammers, pneumatic rammers, trowels, slicks, square corner slicks, lifters, vent rods, floor swab, draw-sticks.)

410. *Q.*—What is a flask?

A.—A set of two or more open frames or boxes used to hold the molding sand.

411. *Q.*—What is the drag or nowel?

A.—The lower frame of a flask.

412. *Q.*—What is the cope?

A.—The upper frame of a flask.

413. *Q.*—What are cheeks?

A.—If the flasks have more than two frames the intermediate frames are called cheeks.

414. *Q.*—What is a snap flask?

A.—A set of frames hinged at one corner and having snaps or catches at the opposite diagonal corner, so that after the mold has been completed it may be easily removed and the flask again used.

415. *Q.*—What is a mold board?

A.—A smooth board or bottom used to set the flask on while making the mold.

416. *Q.*—What is the pouring basin?

A.—A depression made in the sand of the cope to guide the melted metal into the runner.

417. *Q.*—What is the runner?

A.—The passage between the basin and the gate, also called a sprue.

418. *Q.*—What is the gate?

A.—The opening where the melted metal enters the mold.

419. *Q.*—Are the gate and runner the same size?

A.—No, the gate is smaller in section, so that the basin and runner will fill quickly and also so it will break off easily when cold.

420. *Q.*—What is a riser?

A.—A passage made to allow air, steam and foreign matter to escape from the mold and not cause trouble.

421. *Q.*—What is a shrink head?

A.—A passage so arranged as to hold a certain amount of melted metal higher than the mold itself, so that as the metal in the mold cools and shrinks the shrinkage is to some extent replaced by the metal in the shrink head.

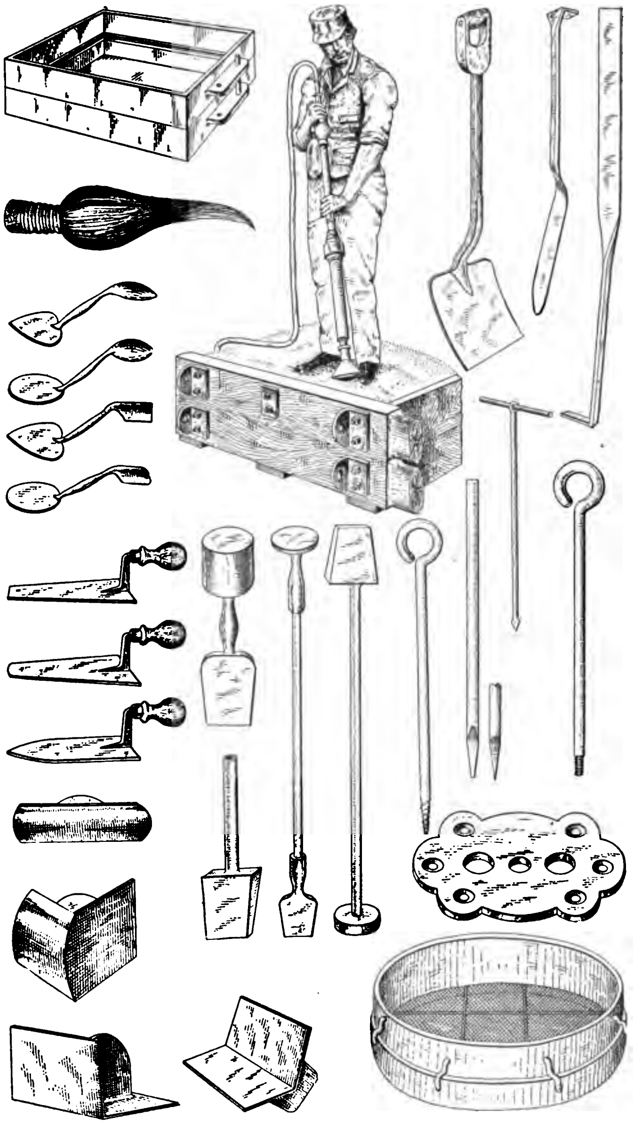


FIG. 45. COMMON TOOLS USED BY MOLDERS.

422. *Q.*—What is a "bedded-in" mold?

A.—One made in an excavation in the foundry floor instead of a built-up flask.

423. *Q.*—What is an open sand mold?

A.—One made without a top or cope.

424. *Q.*—What is a sweep?

A.—A template of a section of the mold, usually rotated or swept around a central pin to produce the desired shape as shown in Fig. 46.

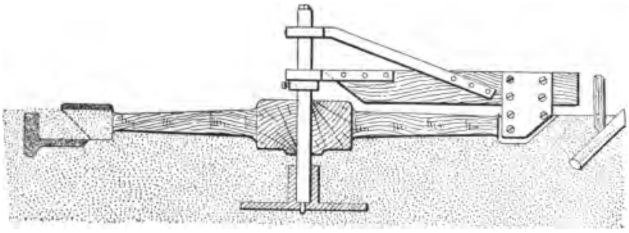


FIG. 46. EXAMPLE OF SWEEP.

425. *Q.*—What is a strickle?

A.—Similar to a sweep, except that it is drawn through the molding sand in a straight or curved line, other than a circular one.

426. Q.—What are gaggers?

A.—L- and Z-shaped iron hooks imbedded in the sand to support and prevent the mold collapsing of its own weight.

427. *Q.*—What are vent wires?

A.—Small, sharp-pointed pieces of wire used to perforate the sand around a mold to assist the escape of air, gas or steam.

428. *Q.*—What are chaplets?

A.—Metal spacers used to hold cores in place. When the metal is poured they weld solidly to it.

429. *Q.*—What is a core?

A.—A core is shapes used to form holes, cavities or pockets in castings.

430. *Q.*—What is a core box?

A.—A wooden or metal mold in which the core is formed.

431. *Q.*—Of what is a core made?

A.—Sand mixed with a suitable binder, then baked to make it firm.

432. *Q.*—What are core binders?

A.—Rosin, flour, linseed oil, glue, molasses or other substances that will bind the sand into a solid cake.

433. *Q.*—What is a core iron?

A.—An iron rod or casting similar in general shape to the core and buried in it to give it stiffness.

434. *Q.*—What is meant by green sand?

A.—Molding sand that is damp enough to hold together properly.

435. *Q.*—What is loam?

A.—A mortar-like mixture usually used to line large molds made of bricks.

436. *Q.*—What is a dry sand mold?

A.—One so made that it may be baked before using, like a core.

437. *Q.*—What is parting sand?

A.—Fine charcoal, sand or other substance sprinkled over the surface of the parts of a mold where they join to prevent their sticking together.

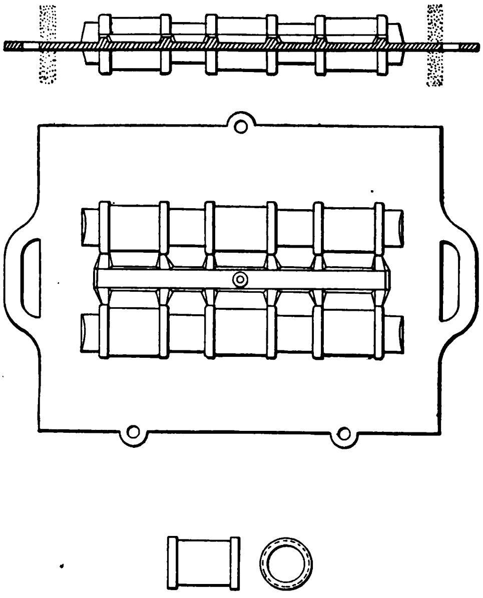


FIG. 47. MATCHBOARDS AND WORK.

438. *Q.*—What are blackings, facings or washes?

A.—Mixtures used to coat the surface of molds so that the casting will "peel" or separate properly from the mold.

439. *Q.*—What is a cold shut?

A.—A flaw or seam caused by streams of metal coming together which are not hot enough to fuse properly.

440. *Q.*—What are scabs and what causes them?

A.—They are projections, like warts, on the surface of the casting, caused by small patches of the mold facing washing off.

441. *Q.*—What are swells?

A.—Bulged places on a casting, caused by insufficient ramming which leaves the walls of the mold too soft to withstand the pressure of the metal.

442. *Q.*—What are chilled castings?

A.—Castings in which certain parts have been chilled and hardened by coming in contact with metal surfaces set into the mold for the purpose.

443. *Q.*—What is multiple molding?

A.—Casting a number of pieces in the same flask at one pouring.

444. *Q.*—What is a sand match?

A.—It is a false cope with a fixed bottom into which patterns are carefully set so as to bring the parting lines into the proper position. The drag is rammed up over this, then inverted and the sand match removed leaving the pattern in the drag, when the cope is rammed up. The sand match is then used to hold the patterns while the next drag is rammed.

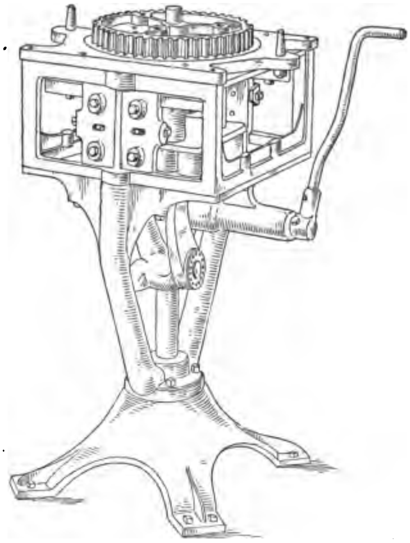


FIG. 48. PATTERN DRAWING MOLDING MACHINE.

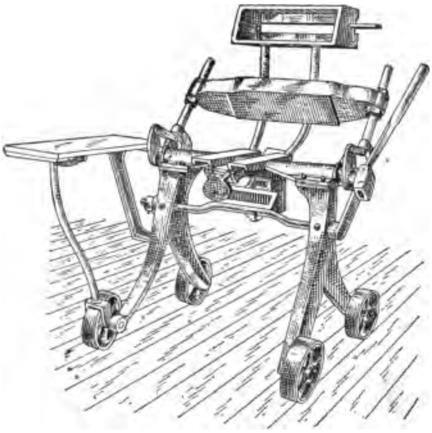


FIG. 49. SQUEEZER TYYE OF MOLDING MACHINE.

445. *Q.*—When is it necessary to use a sand match?

A.—It is used where a number of pieces of the same kind are to be cast and saves the time that would be needed to set the patterns accurately each time. Usually a number of patterns are imbedded in the sand match at once.

446. *Q.*—What is a match board or match plate?

A.—A board or plate of either flat or irregular shape on the opposite sides of which are fastened the two parts of patterns, so that molds rammed up from opposite ends of the board and then fitted together will produce the castings desired. The work and watch boards are shown in Fig. 47.

447. *Q.*—What is a molding machine?

A.—A machine for making duplicate molds quickly and accurately.

448. *Q.*—How many types of molding machines are there?

A.—Three: those designed simply to draw the pattern; those which only ram the flask; and those arranged to do both of these operations, the three types being illustrated in Figs. 48, 49, and 50.

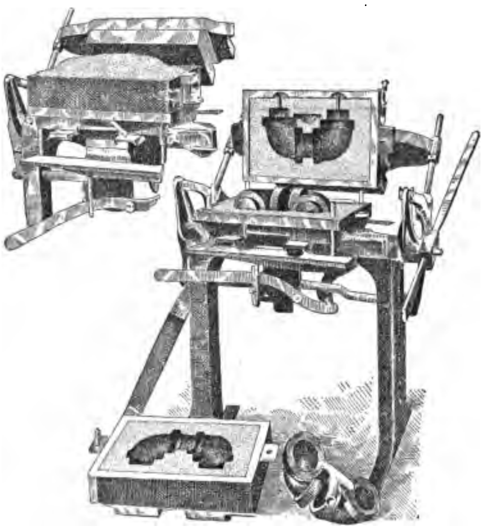


FIG. 50. SQUEEZER WITH DEVICE FOR DRAWING PATTERNS.

449. *Q.*—How are molding machines operated?

A.—Both by hand and compressed air. Rarely by water under pressure.

450. *Q.*—What air pressure is commonly used?

A.—From 80 to 100 lb. per square inch.

451. *Q.*—What is air consumption on small and medium-sized molding machines?

A.—About 4 cu. ft. of free air per minute.

452. *Q.*—What is a vibrator?

A.—A small pneumatic hammer used to jar the pattern on a molding machine when it is drawn.

453. *Q.*—How many blows per minute does a vibrator strike?

A.—From 5000 to 30,000.

454. *Q.*—What is a cupola?

A.—A furnace where the iron is melted in direct contact with the fuel) using forced draft. A common type is shown in Fig. 51.

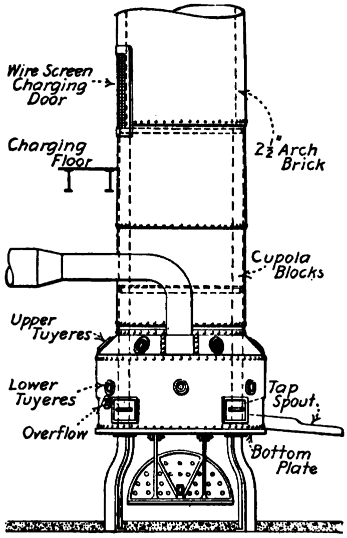


FIG. 51. TYPICAL CUPOLA.

455. *Q.*—What is a bott stick?

A.—A rod on the end of which a handful of clay is placed, used to stop up the hole in the furnace through which the melted iron flows to the ladles.

456. *Q.*—What are ladles used for?

A.—As the metal flows from the spout of the cupola, it is caught in ladles and carried to the molds for pouring. The various sizes of ladles are designated by weight, and vary from 30 lb. to 20 tons capacity.

457. *Q.*—How many kinds of ladles are there?

A.—Four: hand ladle, bull ladle, crane or trolley ladle, and geared crane ladle. These are rated as shown in Table 27.

458. *Q.*—In the ordinary run of castings what chemical elements are usually present?

A.—Carbon, silicon, sulphur, phosphorus and manganese.

459. *Q.*—In what proportions are these found in various irons?

A.—As given in Table 28 taken from Kent.

Type of ladle	How managed	Capacity in lb.	Size in inches			Weight of ladle
			Top	Depth	Bottom	
			Thickness for lining			
Hand ladle.......	Hand shank.......	30–50	7–8	7–8	6–7	15–16 lb.
			3/4	side 1/2	1/2–3/4	
Bull ladle........	Single or double shank.	80 to 350	9–15	9–15	8–13	35–100 lb.
			1 1/4	1/2–5/8	3/4–1	
Crane or trolley ladle with bail.	Bail, with single or double shank.	300 to 2000	14–26	14–26	12–23	115–350 lb.
			1 3/4	5/8–1	1–3	
Geared crane ladle.	Worm gear on heavy bail.	1,000 to 35,000	20–75	20–60	18–66	1,900–7,000 lb.
			2–4	1–4 1/2	1 1/2–5	

TABLE 27.—RATING OF FOUR TYPES OF LADLES.

(Abbreviations, TC, total carbon; GC, graphitic carbon; CC, combined carbon.)

No.	TC	GC	CC	Silicon	Manganese	Phosphorus	Sulphur	
1	3.98	0.39	3.59	0.38	0.13	0.20	0.038	Melts at 2048° F.
2	3.78	1.76	2.01	0.69	0.44	0.53	0.031	Melts at 2156° F.
3	3.88	2.60	1.28	1.52	0.49	0.46	0.035	Melts at 2211° F.
4	4.03	3.47	0.56	2.01	0.49	0.39	0.034	Melts at 2248° F.
5	3.56	3.43	0.13	2.40	0.90	0.08	0.032	Melts at 2280° F.
6	4.39	0.13	4.26	0.65	0.40	0.25	0.038	Melts at 2000° F.
7	4.45	2.99	1.46	0.67	0.41	0.26	0.039	Melts at 2237° F.
8	3.30	2.80	0.50	2.00	0.60	0.08	0.03	Swedish charcoal pig.
9	....	2.25–2.5	0.6–0.8	0.8–1.2	0.4–0.8	0.15–0.4	....	For engine cylinders.
10	3.40	3.40	Trace	2.90	0.50	1.65	0.04	English, high P., No. 1.
11	3.40	3.20	0.20	2.60	0.50	1.58	0.04	English high P., No. 3.
12	....	3.2–3.6	0.1–0.15	2.5–2.8	up to 1.0	1.3–1.5	0.03–0.04	For thin ornamental work.
13	....	3.0–3.2	0.4–0.5	2–2.3	up to 1.0	1–1.3	0.06–0.08	For medium size castings.
14	....	2.8–3.0	0.4–0.6	1.2–1.5	0.6–0.9	0.4–0.6	0.06–0.08	Heavy machinery castings.
15	....	2.5–2.8	0.6–0.8	1.0–1.3	0.5–0.7	0.4–0.7	0.08–0.12	Cylinders and hydraulic work.
16	....	....	....	1.2–1.8	0.4–1.0	0.4–0.7	to 0.06	For hydraulic cylinders.
17	....	2.7–3.0	0.5–0.8	0.5–0.7	0.3–0.5	0.3–0.5	0.05–0.07	For car wheels.
18	....	2.6–3.1	0.6–1.0	0.6–0.7	0.1–0.3	0.3–0.5	0.05–0.08	For car wheels.
19	....	2.5–3.0	0.4–0.9	1.3–1.7	0.5–1.0	0.3–0.4	0.03 max.	Charcoal pig. 1/4 in. chill.
20	....	2.3–2.7	0.5–1.0	1.0–1.5	0.5–1.0	0.3–0.4	0.03 max.	Charcoal pig. 1/2 in. chill.
21	....	2.0–2.5	0.8–1.2	0.8–1.2	0.5–1.0	0.3–0.4	0.035 max.	Charcoal pig. 3/4 in. chill.
22	....	1.8–2.2	0.9–1.4	0.5–1.0	0.3–0.7	0.3–0.4	0.035 max.	Charcoal pig 1 in. chill.
23	3.87	3.44	0.43	1.67	0,29	0.095	0.032	Series A, Am. F'dmen's Assn.
24	3.82	3.23	0.59	1.95	0.39	0.405	0.042	Series B, Am. F'dmen's Assn.
25	3.84	3.52	0.32	2.04	0.39	0.578	0.044	Series C, Am. F'dmen's Assn.
26	....	2.8–3.2	0.5–0.7	1.3–1.5	0.3–0.6	0.5–0.8	0.06–0.10	For locomotive cylinders.
27	....	2.3–2.4	0.8–1.00	1.8–2.0	0.8–1.0	0.6–0.8	0.06–0.10	"Semi-steel."
28	....	2.4–2.6	0.8–1.0	0.9–1.0	0.6–0.7	0.1–0.3	0.04–0.06	"Semi-steel."
29	4.33	3.08	1.25	0.73	0.44	0.43	0.08	A strong car wheel, Cu. 0.03.
30	3.17	2.72	0.45	1.99	0.39	0.65	0.13	Automobile cylinders.
31	3.34	2.57	0.77	1.89	0.39	0.70	0.09	Automobile cylinders.
32	3.5	2.9	0.6	0.7	0.4	0.5	0.08	Good car wheel.
33	3.55	3.0	0.55	2.75	2.39	0.86	0.014	Scotch irons.
34	....	....	....	3.10	1.80	0.90	....	"Am. Scotch" Ohio irons.
35	....	....	....	0.75–1.5	to 0.6	to 0.22	to 0.04	Pig for malleable castings.
36	....	....	....	2–2.5	to 0.7	to 0.7	to 0.15	Brake-shoes.
37	....	....	....	1.2–1.5	0.5–0.8	0.35–0.6	to 0.09	Hard iron for heavy work.
38	....	....	....	1.5–2	0.5–0.8	0.35–0.6	to 0.08	Medium iron for general work.
39	....	....	....	2.2–2.8	to 0.7	to 0.7	to 0.085	Soft-iron castings.

Table 28.—Analyses of Cast Iron.

CHAPTER XII

FORGING, HARDENING, TEMPERING AND HEAT TREATING

460. *Q.*—What is a good way of building a small fire in an ordinary blacksmith's forge?

A.—The hearth of the forge is generally kept filled with cinders even with the top of the rim. These should be cleaned away from the center of the forge, down to the tuyere. Into this cavity place some oily waste, shavings or other easily lighted material. When the blast is started and the stuff well lighted, a little coke is put on top. Over this fresh coal is spread. The fire should not be used till all the coal on the top has been coked. As the fire burns out in the center, the coke which has been forming around the edge is pushed in and more fresh coal added around the outside.

461. *Q.*—How is a large forge fire made?

A.—One good method is to first make up enough coke to last several hours, which is shoveled to one side. Then a large block, the size of the intended fire, is placed on top of the tuyere, and green coal is packed down hard on two opposite sides, forming two mounds of closely packed coal. The block is then taken out and a fire started between the two mounds, coke being added as necessary. This is sometimes called a stock fire, and will last for some time. The mounds keep the fire together and hold in the heat. Of course, for very large work, or where many pieces are to be heated at once, a furnace and ready-made coke are used.

462. *Q.*—How is a forge fire "banked" to make it keep?

A.—The coke should be well raked up into a mound over the fire, and this covered with green coal. If it is desired to keep the fire for some time a piece of wood, preferably hard wood, is thrust down into the center of the fire when banking it.

463. *Q.*—What is meant by the expression "green coal"?

A.—Fine blacksmith's coal which has been dampened with water.

464. *Q.*—In heating iron or steel for forging, should a strong blast be used?

A.—Care should be exercised to not use too much air. Coal requires a certain amount of air to burn properly but with an excess of air, the oxygen is not all burned out, and it passes through and strikes the heated work, forming oxide, or as it is familiarly known, scale. The hotter the work the more easily is oxide formed, and this scale is always a disadvantage on any forging, but is especially so on work to be welded. If it were possible to keep air away from the work entirely, no scale would be formed, even at a high heat.

465. *Q.*—What are some of the more common tools used in the ordinary forge shop?

A.—The cold chisel, hot chisel, and hardie, as shown in Fig. 52.

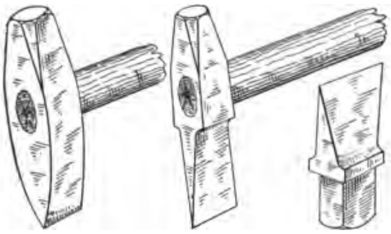


FIG. 52. COLD CHISEL, HOT CHISEL AND HARDIE.

466. *Q.*—How should these be tempered?

A.—They are tempered alike, but the edge of the hot chisel is soon softened by contact with hot metal, while the cold chisel holds its temper. For these reasons the two chisels should never be used in place of each other, for by using the cold chisel on hot work the temper is drawn and the edge left too soft for cutting cold metal, while on the other hand the softer and thinner hot chisel will have its edge turned and ruined.

467. *Q.*—How should cold and hot chisels be ground?

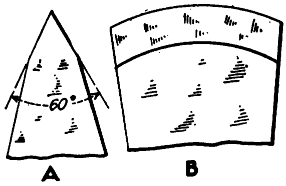


FIG. 53. HOW TO BEVEL EDGES OF COLD CHISELS.

A.—The edge of a cold chisel should be beveled to an angle of about 60 deg. as shown at *A*, Fig. 53, and the edge should be ground in an arc as shown at *B*. Ground this way, the corners do not have a tendency to chip off. Hot chisels should be beveled to an angle of about 30 deg.

468. *Q.*—What is the better way to cut a soft steel or wrought iron bar with a cold chisel?

A.—First cut about one-fourth of the way through the bar on one side. Next make a cut across each end of this cut and then turn the bar over and cut about one-fourth of the way through exactly opposite the first cut. With the cut resting on the edge of the anvil, tilt the bar slightly and strike the projecting end with a sledge. Usually one blow is sufficient. The edge of a chisel should never under any circumstances be driven clear through the stock and allowed to come in contact with the hard face of the anvil. Sometimes when trimming thin stock it is necessary to cut clear through, and for this purpose a soft block of some kind should be laid on the anvil.

469. *Q.*—What are some of the more common types of tongs used?

A.—Tongs are made in almost innumerable shapes and sizes, but three that may be found in almost any forge shop are shown in Fig. 54. *A* is a pair of straight jawed tongs used to hold flat iron; *B* is a pair of bolt tongs which are used for holding bolts or pieces which are larger on the end than through the body; *C* are known as pick-up tongs and are used for handling small pieces, tempering and the like.

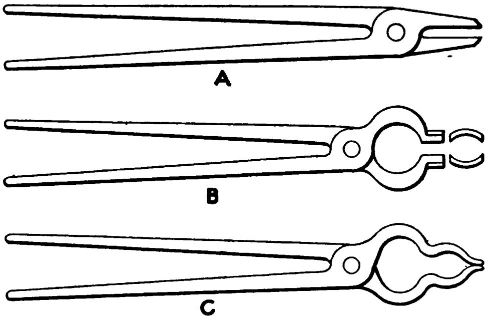


FIG. 54. COMMON TYPES OF TONGS.

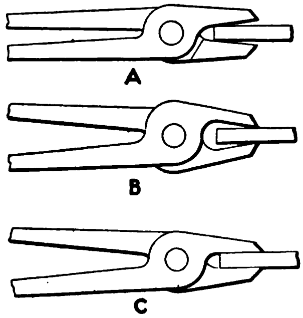


FIG. 55. IMPROPERLY AND PROPERLY FITTED TONGS.

470. *Q.*—In forging a piece is it necessary to fit the tongs to the work and how is this done?

A.—Yes, in order to hold the work securely, the tongs should be fitted.

Poorly fitted tongs are shown at *A* and *B*, Fig. 55, and a fitted pair at *C*. To fit a pair of tongs the jaws should be heated red hot and the piece to be held placed between them and the jaws closed down with a hammer. To prevent the handles being brought too close together a short piece of stock should be held between them just back of the jaws while fitting.

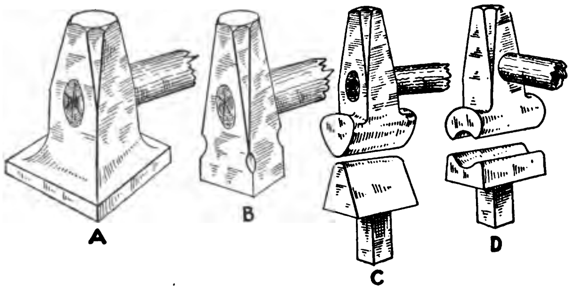


FIG. 56. HAND TOOLS COMMONLY USED IN THE FORGE SHOP.

471. *Q.*—What other hand tools are common to a forging shop?

A.—Flatters, set hammers, fullers and swages, as illustrated at *A*, *B*, *C* and *D*, Fig. 56. The face of the flatter is usually about 2 in. square and that of a set hammer about 1 or 1 1/4 in. square. The set hammer is used for finishing parts that cannot be reached with the flatter. The name "set hammer" is often given to all sorts of tools which are held in place and struck with another hammer. Fullers are used to finish up filleted corners, forming grooves, etc., and a set consists of a top and bottom fuller, the latter being held in the hardie hole of the anvil. Swages are used for finishing round or other shaped work, and are usually used in pairs as shown. A swage block shown in Fig. 57 is frequently used for a variety of work. They are usually made of cast iron and are about 3 1/2 in. thick.

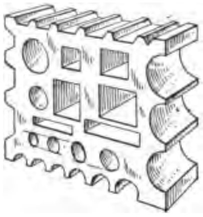


FIG. 57. SWAGE BLOCK.

472. *Q.*—How is the length to cut a piece of stock for a certain bend calculated?

A.—Lay out the piece to be bent on a piece of paper and measure the length of a line following the center of the stock. If one piece is already bent and it is desired to obtain the length of a bar to make another, a good way is to take a piece of soft wire or a piece of string and lay it on the bent piece following the curves and bends, being careful to keep the measuring piece in the center of the stock. Then cut or mark the string or wire even with the ends of the bent piece, and pull it straight. The length will be the length to cut the bar.

473. *Q.*—Does this rule apply to stock that is to be welded, such as a chain link?

A.—Yes, except that allowance must be made for the weld which is a matter of judgment. Of course, the only stock really lost in welding is the amount burned off or lost in scale, so that if the weld is carefully made very slight allowance is necessary.

474. *Q.*—In drawing out a piece of iron or steel, which is preferable, to use the face or horn of the anvil?

A.—For preliminary drawing, the horn is always better, since the curve of the horn assists in stretching the metal in the right direction. Of course the smoothing up must be done on the face.

475. *Q.*—How should stock be drawn to a point?

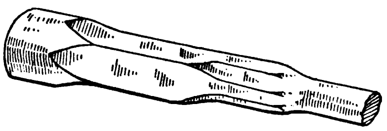


FIG. 58. DRAWING STOCK TO A POINT.

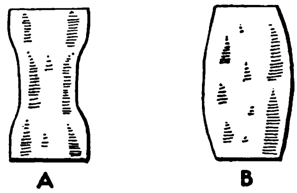


FIG. 59. UPSETTING STOCK.

A.—By first forging it square then octagonal and finally rounding, the process being graphically illustrated in Fig. 58. This prevents the metal splitting, as it is very liable to do if forged round and round.

476. *Q.*—How is it possible to upset a short piece of stock more in the middle than on the ends?

A.—If a short piece is heated all over and then struck light blows, the effect will be as shown at *A*, Fig. 59, but with good heating and heavy blows, the effect is as shown at *B*. Sometimes it is necessary to heat the piece all over, grasp it in the middle with a pair of tongs and dip the ends in water, then upset with heavy blows.

477. *Q.*—How is it possible to punch a hole through hot stock without causing a bulge on one side?

A.—By driving the punch about halfway through the stock as shown at *A*, Fig. 60, then locating by the bulge, drive the punch through from the other side, the slug coming out as at *C*. A properly and improperly punched hole is illustrated at *D* and *E*, respectively.

478. *Q.*—In forging carbon, or as it is commonly known, tool steel, into tools, can it be heated as hot as iron usually is?

A.—Tool steel should not be heated over a good red heat for forging, as it will be damaged if heated white hot. However, it should not be worked at too low a heat or it will check or crack.

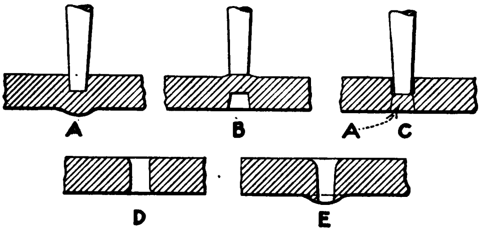


FIG. 60. PUNCHING A HOLE THROUGH STOCK.

HARDENING AND TEMPERING

479. *Q.*—How is it possible to tell the proper hardening heat for a tool steel tool?

A.—The directions are to heat the tool or part to be hardened to a nice cherry red, and then dip in clean cold water till cool; but cherries are all colors from black to white, and considerable practice and judgment is usually needed to get satisfactory results in judging the heat from the color alone. A way that is not subject to light variations and conditions of color is to take advantage of the fact that at the proper hardening heat, steel loses its magnetic qualities, and will no longer be attracted by a magnet. This is done by hanging an ordinary horseshoe magnet by a string, close to the forge, and at a level easily reached. As the tool heats up, hold the heated part next to the magnet frequently and as soon as the attraction ceases, plunge the tool at once into the cooling bath. Of course, the tongs and unheated parts of the tool will attract, so care must be taken to make allowance for this, and only bring the part to be hardened in contact with the magnet and keep the rest as far away as possible.

480. *Q.*—Are there any other ways of heating tools to the proper hardening temperature?

A.—Yes, there are several. One of the more common ways is to immerse the tools in hot lead until they are as hot as the lead bath, the temperature of which is tested by means of a special thermometer, or a pyrometer.

481. *Q.*—After a tool is hardened how may it be tempered so as to not be too hard and brittle?

A.—A great deal depends on the size and shape of the tool, and what it is to be used for. Lathe, planer tools and the like, are often hardened and tempered at one heat. To do this, they are heated back some distance from the cutting point, then the point is immersed in the cooling bath and as soon as it is withdrawn, the black oxide is polished off with emery cloth or an emery stick, and as the heat from the shank of the tools runs toward the point, the color is watched and as the proper color, usually straw color, appear at the cutting part, the tool is dipped all over.

Where tools are hardened all over, and often when not, the temper is drawn to the right degree in an oil bath heated to the correct point. However, in the common forge shop an oil bath is not usually available and drawing by color must be the guide. The hardened piece is first polished, and if small, or easily handled, may be laid on a heated cast-iron plate or sheet of boiler iron laid over the forge fire. Where a piece is to be drawn all over care must be taken to move it around and not let it get too hot in spots. Hot tongs may also be used to draw some parts, such as the neck of a tap or a small punch. Where the smoke of a forge obscures the color, a little lard oil rubbed on after polishing will help.

In the case of a good-sized milling cutter or the like, a method sometimes followed to harden and temper at the same heat is to heat the tool carefully and evenly, as usual, and when hot enough plunge it in cold water, but not long enough to become completely cold, it being drawn out the instant the "singing" stops, and plunged into lard oil and left in for a very short time only, the time depending on the size of the tool. The tool is then held until the oil smokes evenly all over, when it is plunged into the water and cooled. This method usually requires considerable practice to give satisfactory results.

482. *Q.*—How is a spring tempered?

A.—Spring tempering is known as "blazing" or "flashing." The spring is heated and hardened in an oil bath (use lard not mineral oil). Then the spring, still wet with oil, is re-heated carefully in the blaze of the forge until the oil blazes up, when it is plunged again into the oil for an instant, and this process is repeated three or four times till the oil blazes evenly all over the entire spring at the same time.

483. *Q.*—Where one must judge the proper temper by color alone, what colors are suitable for different tools?

A.—Table 29, taken from Bacon's "Forge Practice" not only tells the colors for different tools, but also the actual temperature, as well as other means of testing:

Kind of tool	Temperature, Fahr.	Color	Action of file	Other indications
Scrapers for ordinary use......	200°	....	....	Water dries quickly.
Burnishers..................				
Light turning and finishing tools......................	430°	Very pale yellow.	Can hardly be made to catch.	Lard oil smokes slightly.
Engraving tools..............				
Lathe tools.................	460°	Straw-yellow.	Can be made to catch with difficulty.	
Milling cutters...............				
Lathe and planer tools for heavy work...............				
Taps.......................				
Dies for screw-cut'g..........				
Reamers....................				
Punches.....................				
Dies........................				
Flat drills..................				
Wood-working tools..........	500°	Brown-yellow.		
Plane irons..................				
Wood chisels................				
Wood-turning tools...........				
Twist drills..................				
Sledges.....................				
Blacksmiths' hammers........				
Cold chisels for very light work.	530°	Light purple.	Scratches.	
Axes.......................	550°	Dark purple.		
Cold chisels for ordinary use...	....	Blue, tinged slightly with red.		
Stone-cutting chisels..........	....	....	Files with great difficulty.	
Carving knives..............				
Screw drivers................				
Saws........................				
Springs.......................	580°	Blue.	Files with difficulty.	Lard oil burns or flashes.
	610°	Pale blue.		
	630°	Greenish-blue.		

TABLE 29.—TEMPERING COLORS FOR VARIOUS TOOLS.

484. *Q.*—What is case hardening?

A.—It is the process of hardening the outside of wrought iron or machine steel by the use of cyanide, ground bone or some other substance containing carbon.

485. *Q.*—Where cyanide of potassium is used, how is it done?

A.—This is used when only a very thin shell of hardness is desired. The piece to be case-hardened is heated to a bright red, withdrawn from the fire and sprinkled with cyanide until it is covered where desired. Then the piece is again placed in the fire to allow the carbon in the cyanide to soak in. As it heats up it is withdrawn, again covered with cyanide and plunged in water.

Another method is to melt and heat the cyanide red hot in a ladle or pot. The pieces to be hardened are heated and placed in the cyanide and left there for several minutes. They are then taken out and plunged in water.

486. *Q.*—How are pieces case-hardened by the use of bone?

A.—The pieces are packed in an iron box or tube so as to be completely surrounded with plenty of ground bone. There should be, as a rule, about 3/4 in. of bone between the pieces and about an inch next to the sides of the box. The box is then sealed with fire clay to exclude the air, and heated in a furnace to a good red heat for several hours, the time depending on the depth desired, then the contents dumped into water.

487. *Q.*—What is meant by water annealing?

A.—This is an emergency method of annealing that leaves a tool soft enough to be worked, though not as soft as regularly annealed steel, and it is not recommended except in case of necessity. The method is to heat the steel to a good red heat and then hold it in a dark place and just as the color "dies" plunge in water.

488. *Q.*—What other methods of annealing are used in the ordinary shop?

A.—One of the most common is to heat the tool to a good even red and bury in a box of slaked lime, leaving it until cool. If it is desired to anneal a tool or piece of steel so that no scale will be formed, or so the air cannot come in contact with it, a good way is to pack it in a piece of gas pipe filled with slaked lime, a cap being screwed loosely over each end or plugs inserted. Then the whole thing is heated and buried in lime till cool.

489. *Q.*—What is the difference between annealing and heat treatment of steel?

A.—Properly speaking, heat treatment of steel covers the whole range of its manipulation, but as understood among mechanics, heat treatment is a process for rearranging the molecules or crystals, after the steel has been subjected to a high heat or some mechanical process, and consists of heating the steel to a few degrees above the critical point and then allowing it to cool, after which it may be hardened or otherwise treated. Annealing, on the other hand, is distinctly a softening process.

CHAPTER XIII

ENGINE LATHE WORK

490. *Q.*—What are the two classes of engine lathe work?

A.—Center work, and faceplate or chucking work. Center work means work that is turned on centers, and is very important if future operations are to be done on the same piece. Faceplate or chucking work is usually employed in such cases as boring cylinders and bushings, facing gear blanks, and boring the hubs, and similar work. In center work it is important that both centers be true and at the same angle as the counter-sunk end of the piece being turned. The standard angle is 60 deg.

491. *Q.*—How are the centers made?

A.—At the present time lathe centers are usually both hard, although before the days of center grinders it was customary to leave the head or live center soft and only harden the tail or dead center on account of the wear which came on it. Both centers should be ground after hardening to take out any spring which may occur. The live center should run perfectly true or it will impart an eccentric motion to that end of the piece being turned. Both centers should line up for height and also sidewise.

492. *Q.*—Is there any rule for the sizes of centers in work to be turned?

A.—The size of the center should vary with the size of the work being turned, and in some cases with depth of the cut. A heavy cut requires better support on the centers, and they should be correspondingly deeper. As a suggestion, work 1/4 in. in diameter should use a 1/16 in. center drill, and the large diameter of the countersink should be about 7/64 in. On 1-in. work the center drill should be 5/64 and the countersink 3/16 in.; while on 3-in. work a 3/16 in. center drill can be used, and the outer diameter of the countersink be 7/16 in.

493. *Q.*—What about lubricating the lathe centers?

A.—Only the dead center requires lubricating, and care should be taken that a perfectly clean lubricant is used. Chips sometimes get into the oil used for this purpose and not only throw the work out of true, but also score the lathe center. A good lubricating oil is usually sufficient, although on extremely heavy work, such as chilled rolls, red or white lead is used to advantage. In such cases the center should be large enough to carry the load easily, not only considering the weight of the piece, but also the thrust of the tool against the center.

494. *Q.*—What are the vital points in a lathe?

A.—Probably the bearing should be considered first. The spindle should turn freely and at the same time should rotate with a perfectly even motion, as any jump or play will show in the work and make it impossible to turn a piece even approximately round. Next the ways should be true, the spindle have sufficient belt power to drive the work under all conditions, the feed strong enough to carry the tool into the work, and there should be no play in the parts supporting the cutting tool.

495. *Q.*—How important is the tool?

A.—The lathe tool is perhaps the one final point in lathe work. Unless it is rigidly supported it will spring and dig into the work, which is the cause of more breakage than almost anything else. Next the tool point must be of a good easy cutting shape and have sufficient hardness and toughness to withstand the cutting strain. A tool should stand up at least an hour between sharpenings and in most cases an hour and a half is considered as the economical limit; this means that it is more economical to run at a little slower speed and feed and make the tool last an hour, than to run at a higher speed and feed and change the tool every twenty minutes. The time lost in changing and resetting tools, as well as in grinding, usually more than offsets the advantage of the higher speed.

496. *Q.*—What is the field of the engine lathe at present?

A.—Since the advent of economical grinding, engine lathe work in many cases is becoming a preliminary operation and is not being used to finish its work, but only to prepare it for the grinder. On the other hand its value in many cases of plain turning is being more and more appreciated by some of the large shop managers. There are instances in which a plain engine lathe is competing successfully with the turret and automatic machine on certain classes of work. The engine lathe has never received the attention it deserves as a tool for rapid production, in the way of introducing special fixtures and tools for its use.

497. *Q.*—How is taper work produced?

A.—With the lathe centers exactly in line a piece may be turned perfectly straight. This is a very difficult condition to attain, although it is comparatively easy to turn sufficiently straight for most purposes. Any deviation from exact alignment will produce taper work, and this is taken advantage of to turn any desired taper without the aid of any attachment.

498. *Q.*—How are tapers produced?

A.—Tailstocks are provided with side adjustment, and by moving the tail center toward the cutting tool, a taper will be produced which is small at the tail end and large toward the head. By moving the tailstock in the other direction the taper will be larger at the tailstock.

To turn any desired taper the tailstock must be set over one-half the amount of taper, figured by the length of the whole piece. This will be given in detail under the head of shop computation.

499. *Q.*—When turning a number of pieces to the same taper, which is best, a taper attachment for moving the tool correctly, or to set over the tail center?

A.—The taper attachment by all means, as any variation in the length of the turned pieces would make a difference in the taper when the tail center is set over.

500. *Q.*—How does an engine lathe differ from a hand or bench lathe?

A.—According to the old definition, the term "engine lathe" designated a lathe having a tool carriage and equipped for cutting threads. Hand or bench lathes were not so equipped and could only be used with hand tools. The later development of bench lathes has in some instances equipped them with a lead screw for feed and thread cutting, so that the former distinction does not hold. In the great majority of lathe work to-day, however, the engine lathe never cuts a thread.

501. *Q.*—What is a worm-geared apron?

A.—The apron of the engine lathe is that portion of the carriage which contains the gearing and other mechanism for transmitting the feed of either the feed rod or lead screw to the lathe carriage. A worm-feed apron is one in which a worm slides on the feed rod (which is sometimes also the lead screw) and transmits its power through the medium of a worm and worm-gear. Others use bevel gears in place of the worm and secure their gear reduction by the use of spur instead of worm-gears.

502. *Q.*—What is meant by back gearing?

A.—Back gearing is a device for reducing the revolutions of the spindle while maintaining the higher belt speed on the lathe cone or pulley. A back-geared lathe is one in which there is a single reduction of gearing and is most common. There are, however, many lathes having double reduction, while some have even three and four reductions of speed through back gearing. In these cases they are designated as double, triple, or quadruple back-geared lathes. The object is to maintain the high velocity so as to secure its power, but to reduce the motion of the lathe spindle and its work to secure the desired cutting speed on large diameters.

503. *Q.*—What are proper speeds and feeds for lathe work?

A.—These vary between such wide limits that it is impossible to set any exact figure. Even assuming that the lathe and the lathe tool will stand the maximum speed, we have to consider the character of the work to be turned, as there are many cases where the castings are light and a heavy cut would distort or break them. Then, too, the hardness, or rather the "cutability" of the metal varies very widely, and occasionally this is found in the same piece. This demands a difference in speed, or feed, or both, which must be varied according to the portion of the work being turned.

504. *Q.*—Are there no general speeds which can be recommended?

A.—On low carbon steel a lathe speed of 100 ft. per minute can usually be maintained with a high speed tool; in fact, there are many cases where work is being run at 150 and even 200 ft. per minute with a fairly heavy cut. On light finishing cuts, speeds as high as 300 ft. per minute are used in some cases, but it is probable that 100 ft. per minute is nearer an average. On cast iron a slower speed is generally necessary, owing to the abrasive action of the cast iron on the tool point. While cast iron can be turned in some cases at 150 ft. per minute, there are probably more cases where 50 to 75 ft. is a safer speed to use. These depend on the depth of the cut and the feed, which directly influence the amount of heat generated, this having a direct influence on the life of the tool.

505. *Q.*—Can taper holes be bored in a lathe?

A.—In all boring, whether straight or taper, the work must be held either on the face plate or in a chuck, so that it is not influenced by the tail center. In the case of large holes, however, it is sometimes the practice to use a boring bar between the lathe centers, to set over the tailstock the desired amount of taper and feed the cutting head along the bar either with a star feed or by direct connection with the tool post, where the hole is short enough to allow this to be done.

Another way of boring a taper hole is to use the compound rest, set off to the proper angle, and feed the tool in by hand. Where many holes of this kind are to be bored, a power feed is sometimes rigged up on the feed screw of the compound rest.

506. *Q.*—How should the tool be set to cut taper threads?

A.—In cutting taper threads, such as pipe threads or taper threads for any purpose, the thread tool should be set square with the axis of the work. Some make the mistake of setting it square with the surface of the work, which is not correct, as can easily be shown by drawing a diagram where an excessive taper is cut. On ordinary taper threads, such as that used for piping, there is probably not enough difference to be especially noticeable.

507. *Q.*—Is there an easy way to test the accuracy of a lathe feed screw?

A.—Probably the easiest way is to fasten a clamp securely on the lathe bed and bring the carriage up to it, using a piece of tissue paper so as to feel the contact between the lathe and the stop. Then turn the lead screw the exact number of revolutions to move the carriage 1, 2, 3, or 4 in., as desired, and use a standard length distance piece between the stop and the carriage, again using the tissue paper as a feeler. This will allow you to test the lead of the screw with considerable accuracy and without special appliances. If you wish to know the error per foot it may be better to use a distance piece just 12 in. long; but as the error probably varies instead of being constant, it is well to take measurements at various points along the lead screw.

508. *Q.*—Can chucks and faceplates be used interchangeably with good results?

A.—There are many cases where lathe chucks and faceplates are interchanged with fair success. This is particularly true of chucks, although it is not to be expected that they will run equally true on either lathe. In the case of faceplate work where extreme accuracy is desired and this accuracy depends upon the work being located on the faceplate, interchange is impossible unless the faceplate is faced every time it is put on the lathe, so as to be perfectly true for the job that is to be done. In fact, those who aim to secure extreme accuracy always face off the faceplate every time it is put on the same lathe, and it is only in this way that they are able to secure the accuracy they desire.

509. *Q.*—Should a lathe tool always be set at the center?

A.—In practice it is often found advisable to set the lathe tool a little above the center, but very seldom advisable to set it below. In the case of turning tapers, however, the lathe tool should be set as near the center as possible, if it is desired to have an accurate taper. Unless this is done the taper changes slightly with every cut. This can be proved by exaggerating the conditions and setting the tool 1/2 in. below or above the center, and comparing the taper it turns with a taper turned with the tool at the center, the tailstock being exactly the same in both cases. In facing off large work it will often be found more advantageous to set the tool above center.

510. *Q.*—What is meant (in screw cutting) by pitch and lead?

A.—In the case of single threads they are both the same; the lead, however, is the distance a nut will travel at one revolution, and the pitch is the distance from one thread to the next. The lead of a triple thread is 3 times as great as that of a single thread of the same pitch.

511. *Q.*—Which is most advantageous, a heavy cut and light feed, or a light cut and heavy feed?

A.—This may depend entirely upon the special conditions. If it is a lumpy casting or forging, it is usually better to take a cut heavy enough to get under the scale, even if the feed must be quite fine to do this, as it is much easier on the tool. Where this factor does not enter into the work, it is perfectly safe to use any combination of cut and feed which will secure best results. For finishing work a light cut and fast feed is probably best in most cases, the same as it is in planer work.

512. *Q.*—Is it advisable for an operator to lean on the tool carriage during a cut?

A.—No. It is better, if necessary to watch his work closely, to lean on the tailstock, as leaning on the tool carriage is bad practice.

513. *Q.*—Is it good practice to do grinding on a lathe?

A.—As a rule grinding on a lathe is exceedingly bad practice. When grinding centers, all parts exposed to the flying abrasive should be covered with cloth or waste in order to keep it from working into the mechanism.

514. *Q.*—When necessary to use a file or other tool on a lathe, where should they be placed when not being used?

A.—It is a good plan to provide a wide board or tray to hold tools that would otherwise be laid on the ways or polished surfaces of the lathe.

515. *Q.*—When turning or boring heavy faceplate work that is off center, how is it balanced and why?

A.—It is balanced by bolting pieces of iron to the faceplate in such a way as to counterbalance the off center weight of the work. This is done so that as the work revolves, the unequal weight of the work will not have a tendency to throw out of center and spring the lathe parts, or cause other trouble.

516. *Q.*—In truing up work in an independent-jawed chuck, what is the better way to proceed?

A.—Set the piece in as near true as the eye can judge, and tighten the jaws just enough to hold it nicely. Next revolve the chuck, and with a piece of chalk mark the high spots, then loosen the jaw or jaws on the side opposite the chalk marks and tighten those on the same side with it. After the piece runs almost true, any slight eccentricity may be taken out by tightening the jaw on the chalked side very tight and then slightly loosening the opposite one. Judgment must, of course, be used when loosening a jaw, not to loosen it so much as to allow the work to drop out. Hammering should also be avoided, if possible, though a lead hammer is commonly used to assist in lining up a piece of work on the jaws.

CHAPTER XIV

PLANING, SHAPING, SLOTTING AND BROACHING

517. *Q.*—What classes of work are usually done on a planer?

A.—Generally speaking, all broad flat surfaces and particularly such parts having sliding surfaces, pieces that are bolted together for alignment, and all parts requiring an accurate surface.

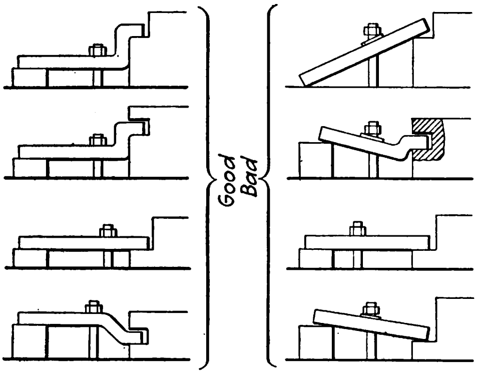


FIG. 61. PLACING TOE CLAMPS ON PLANERS.

518. *Q.*—How is work held in a planer table?

A.—Commonly by means of straps or clamps of various kinds.

519. *Q.*—Where toe clamps are used, what is the correct way of placing them?

A.—As shown in Fig. 61.

520. *Q.*—Are clamps or straps all that are necessary to hold a piece securely?

A.—Pins or plugs should be placed in holes in the table, against which the work is butted, to prevent the thrust of the cut shifting the work. For some work an angle plate is bolted to the table to take the thrust.

521. *Q.*—What is meant by string planing?

A.—Planing a number of duplicate pieces, placed in a row.

522. Q.—How are pieces held when string planing?

A.—In different ways. Sometimes a special holding fixture is used, and sometimes they are located and clamped individually. In some cases the use of a holding fixture is done away with by casting small lugs on the pieces, for the toe clamps. These lugs are made so as to be easily knocked off after the work is done.

523. *Q.*—Is a vise ever used to hold work on a planer?

A.—Occasionally, but not in many places.

524. *Q.*—Are dividing heads ever used on planers?

A.—Regular planer indexing centers are supplied by manufacturers for the purpose.

525. *Q.*—Is a magnetic chuck ever used for planer work?

A.—Yes. Sometimes to hold thin work, but the tool thrust must be taken care of as in clamping.

526. *Q.*—Where it is necessary to plane keyways in a number of shafts, what is a good way to hold them?

A.—As shown in Fig. 62.

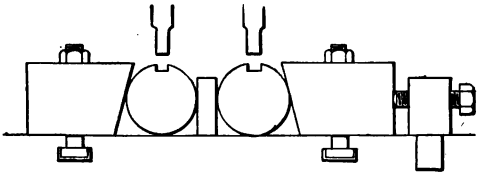


FIG. 62. CUTTING KEYWAYS ON THE PLANER.

527. *Q.*—What are good practical planing speeds for various metals?

A.—In Table 30 is given the practice of some of the best shops:

Cast iron, roughing	40 to 50 ft. per minute.
Cast iron, finishing	20 to 25 ft. per minute.
Steel castings, roughing	30 to 35 ft. per minute.
Steel castings, finishing	20 ft. per minute.
Wrought iron, roughing	30 to 45 ft. per minute.
Wrought iron, finishing	20 ft. per minute.
Machinery steel	30 to 35 ft. per minute.
Bronze and brass	50 to 60 ft. per minute.

TABLE 30.—PLANING SPEEDS FOR VARIOUS METALS.

528. *Q.*—At what speed is the table returned?

A.—About 75 to 100 ft. per minute is the average present practice.

SHAPER WORK

529. *Q.*—What is the difference between the action of a planer and a shaper?

A.—In the planer the work moves to the tool, but in a shaper the tool moves over the work.

530. *Q.*—Into what two classes are shapers divided?

A.—Into stationary and traveling head. This refers to a side movement of the head.

531. *Q.*—What is meant by a crank shaper?

A.—One in which the ram is driven by some form of crank motion.

532. *Q.*—Are the rams driven in any other way?

A.—Formerly a rack-and-pinion was used, the reverse being obtained by means of shifting belts like a planer, but this is seldom found at present.

533. *Q.*—How many strokes per minute will the ram of a shaper make?

A.—The strokes of a well-known make are from 10 to 120 per minute for the 14-in. size, and from 6 to 100 per minute on the 24-in. size.

534. *Q.*—What is the ratio of the cutting speed to the return speed?

A.—The average is about 1 to 2.

535. *Q.*—What is a draw-stroke shaper?

A.—In ordinary shapers the cutting is done on the outward stroke whereas in the draw-stroke shaper the reverse is the case. This type is especially adapted for heavy work.

536. *Q.*—Can anything but flat work be machined on a shaper?

A.—Yes. By the use of attachments supplied by the different makers, various shapes may be machined, such as concave, convex and round; also keyways and gears.

537. *Q.*—How may a keyway be cut in a gear or pulley without special attachments?

A.—Strap the work to an angle plate and work out the keyway with a long tool properly ground. The angle plate should have a hole in it coincident with the hole in the work, both for tool clearance and the purpose of watching the cut.

SLOTTING

538. *Q.*—What is a slotter?

A.—A slotter is practically a vertical shaper.

539. *Q.*—For what is a slotter used?

A.—As the name implies, it is used for slotting out, or working out various pieces of work, such as the slots in locomotive links, various parts of locomotive frames, driving boxes, mud rings and heavy work of this character; keyways in gears, etc.

540. *Q.*—Into what general classes may slotters be divided?

A.—Into belt- and motor-driven; crank- and screw-operated; portable and stationary.

541. *Q.*—What are portable slotters?

A.—In the common or shop sense, a portable slotter is one that may be moved around on the surface of a large floor-plate and set wherever it is necessary to machine a part of a large casting. Often they are set inside of a large casting, as for instance, in cutting out dovetail slots in large generator frames.

542. *Q.*—What is a traveling head slotter?

A.—It is a machine built something on the lines of a traveling head shaper, and is intended for work which cannot be handled very well on the standard machines.

543. *Q.*—What is an armor plate slotter?

A.—It is a machine made very much like a large planer, with a traveling or movable table. The slotting head is carried on a crossrail, which may be tilted so as to machine off the edges of armor plate at any desired bevel.

544. *Q.*—What is the range of strokes in slotters?

A.—One well-known concern regularly builds slotters of various sizes, the maximum strokes of which range from 6 in. to 8 ft.

545. *Q.*—How is the size of a slotter quoted?

A.—As a rule the quoted size of a slotter is the same as its maximum stroke. For instance, a 96-in. slotter will make a cut 96 in. in length.

BROACHING

546. *Q.*—What is meant by a broaching machine?

A.—It is a machine used to work out a hole or slot, by means of a tool or tools having a number of teeth of increasing size forced through in order to give the desired outline.

547. *Q.*—How are these tools forced through?

A.—They may be either pushed or pulled through.

548. *Q.*—What kind of machines are used to push broaching tools or broaches, through the work?

A.—The machine may be a punch press; screw press; hydraulic press; common mandrel press, or some other similar type.

549. *Q.*—Into what classes are the draw broaching machines divided?

A.—The standard machines are either of the screw or the rack-and-pinion type.

550. *Q.*—For what is a broaching machine especially adapted?

A.—For working out keyways in gears, pulleys, handles and the like; for round, square, hexagon or odd-shaped holes; for cutting multiple splines and similar work.

551. *Q.*—What is one great advantage of the broaching method over others for certain classes of work?

A.—The fact that the cutting action of the broach tends to bind or clamp the work to the thrust plate, making it unnecessary in most cases to clamp the work, only a locating work bushing being used to guide the tool.

552. *Q.*—Of what are broaches made?

A.—This depends on the purpose for which they are to be used. A keyway broach may be made of a bar of rectangular tool steel of the right size, made to slide in the slot of a guide bushing, or it may be made of a rectangular bar of tool steel set into a slotted holder made of machine steel. They are also often made of high-speed steel in the same way.

553. *Q.*—Are broaches for round or square holes ever made from solid bars?

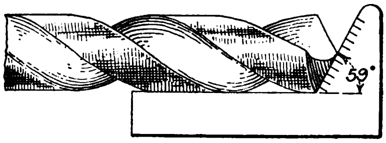


FIG. 63. PROPER ANGLE TO GRIND TWIST DRILLS.

A.—Yes, generally, unless the holes to be broached are large.

554. *Q.*—How is a square or hexagon-shaped broach made?

A.—It is usually first planed or milled to shape and then the teeth are milled or turned in it.

556. *Q.*—Why are the blanks machined to shape before the teeth are cut?

A.—The edges of the teeth are not so apt to be torn in this way.

557. *Q.*—In turning the teeth, how are the broaches prevented from springing?

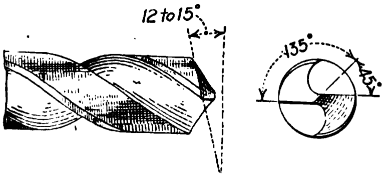


FIG. 64. PROPER CLEARANCE ALLOWANCE FOR TWIST DRILLS.

A.—By the use of a cat-head in the steady rest, or in case of a round blank, by a follower rest.

558. *Q.*—How many broaches are needed to finish a hole?

A.—This all depends on the length and diameter of the hole and the metal cut, but as a general rule, a hole not over 6 in. in length may be finished in cast iron by a pull broach in one cut. Tougher metal or a great degree of accuracy may require two or more broaches.

559. *Q.*—How much do the teeth of a broach increase in size?

A.—Commonly from 0.002 to 0.004 in.

560. *Q.*—Do all the teeth increase in size?

A.—It is the usual custom to make the last three or four teeth the same size and prolong the life and accuracy of the broach.

561. *Q.*—When a broach is undersize, must it be thrown away?

A.—The usual practice is to regrind an undersize broach so that it may be used either for a roughing broach, or for a smaller-sized hole.

CHAPTER XV

DRILLING, REAMING AND TAPPING

562. *Q.*—How many types of drills are there?

A.—Flat, flat twist, fluted straight, fluted twist, gun drills and minor variations of these.

563. *Q.*—How are flat twist drills made?

A.—By twisting flat stock to the desired spiral while hot.

564. *Q.*—How are fluted straight drills made?

A.—They are either made from bars drawn to the desired shape, or else the flutes are milled lengthwise of the stock.

565. *Q.*—How are fluted twist drills made?

A.—Either from straight fluted stock, or else from round stock and the flutes milled in. Drills with more than two flutes are always milled.

566. *Q.*—What are drills with more than two flutes used for?

A.—Usually for drilling out cored holes in castings, or following another drill, where a two-flute drill would be apt to catch or spring and break.

567. *Q.*—What kind of steel is used to make drills?

A.—Either high-carbon tool or high-speed steel.

568. *Q.*—What is the proper temper for a drill for all-round use?

A.—Usually a dark straw or brown color, or somewhere between 470 and 490 deg. F.

569. *Q.*—To what angle is an ordinary twist drill ground for cast iron or steel?

A.—59 deg., as shown in Fig. 63.

570. *Q.*—What is the best all-round clearance to grind on a drill?

A.—About 12 deg. For softer metals about 15 deg., as shown in Fig. 64.

571. *Q.*—Does this mean that the entire back of the lip should be this amount?

A.—No. Only back of the cutting edge, as it should increase to about 45 deg. at a line across the web.

572. *Q.*—Is a drill ground differently for brass than for iron?

A.—It is common practice to grind the front of the cutting edge parallel with the axis of the drill, as shown in Fig. 65.

573. *Q.*—How is a drill ground for thin stock?

A.—The same as for brass.

574. *Q.*—How fast should a drill be run in steel or cast iron?

A.—A carbon drill should be run at a speed that will give about 40 ft. per minute, or about 1834 r.p.m. for a $\frac{1}{16}$-in. drill, in steel. For cast iron, about 35 ft. per minute may be used.

575. *Q.*—How fast should a drill be run in brass?

A.—About 60 ft. per minute is a good speed for ordinary brass, or 3668 r.p.m. for a 1/16-in. drill.

576. *Q.*—Are the foregoing speeds suitable for high-speed steel drills?

A.—High-speed drills will stand about double the speeds quoted.

577. *Q.*—What is meant by the feed of a drill?

A.—Drill feed is usually given in parts of an inch per revolution; 0.004 to 0.007 in. for drills of 1/4 in. or smaller, and 0.007 to 0.015 in. for larger sizes. As before, the amount may be doubled for high-speed drills.

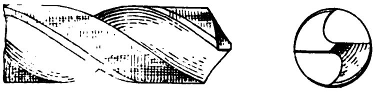


FIG. 65. PROPER ANGLE TO GRIND TWIST DRILLS FOR USE ON BRASS.

578. *Q.*—What lubricants are used for drilling different metals?

A.—Cast iron is usually drilled without lubricant; for steel, lard oil or soap water; aluminum, soap water or kerosene; for tool steel, lard oil or turpentine, and brass, oil, soap water or dry.

REAMERS AND REAMING

579. *Q.*—Into what two general classes may reamers be divided?

A.—Into hand and machine reamers.

580. *Q.*—Into what other types may each of these classes be divided?

A.—Into solid and adjustable.

581. *Q.*—What is a rose reamer?

A.—It is a machine reamer which cuts only on the end.

582. *Q.*—What relation does the number of flutes of a rose reamer usually have to the cutting edges?

A.—There are usually just half as many flutes as cutting edges, the number of cutting edges usually running from 6 on the 1/2-in. sizes and smaller, up to 16 on the 3-in. sizes.

583. *Q.*—What is a shell reamer?

A.—It is a reamer made in tubular form, to fit over a machine steel shank or holder, a number of reamers usually fitting the same holder.

584. *Q.*—What is an adjustable reamer?

A.—It is one in which the cutting edges may be adjusted within certain limits. One of its great advantages is that it may be reground and again brought to exact size, which cannot be done with a solid reamer.

585. *Q.*—Are the flutes of a reamer odd or even?

A.—Generally even, as it is easier to measure the sizes.

586. *Q.*—In an even fluted reamer are the lands or cutting edges evenly spaced?

A.—Not as a rule. The ones diametrically opposite are alike, but the spacing generally increases throughout each half.

587. *Q.*—Why is this done?

A.—It prevents chattering, caused by the teeth of an evenly spaced reamer following the errors of the preceding tooth.

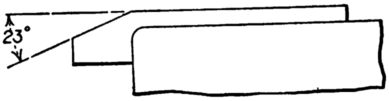


FIG. 66. PROPER ANGLE FOR CHUCKING REAMER CUTTERS.

588. *Q.*—What is the proper angle to grind the ends of the cutters on a chucking reamer?

A.—According to experiments made by the Cincinnati Milling Machine Co., the proper angle for a chucking reamer used on gray iron and bronze is as shown in Fig. 66., and for steel, as shown in Fig. 67.

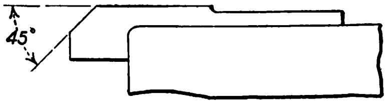


FIG. 67. ANGLE ON CHUCKING REAMER CUTTERS FOR STEEL.

589. *Q.*—What is the allowance for width of land on reamer blades?

A.—According to the above authority: 0.025 in. for gray iron or bronze and 0.005 in. for steel.

590. *Q.*—What amount should be left to be taken out by a reamer?

A.—This depends on the nature of the work and the closeness of the limits to be maintained, but from 0.002 to 0.005 in. is a fair amount, though some authorities say 0.0045 in. for a 3/16- in. reamer, up to 0.013 in. for a 3-in. one.

591. *Q.*—What is the proper speed and feed for reaming?

A.—In Table 31, taken from the American Machinist Handbook, is given the desired information:

Diameter of reamer	Feed per revolution	Amount to remove on diameter	Revolution per minute		Diameter of reamer	Feed per revolution	Amount to remove on diameter	Revolution per minute	
			Screw stock at 40 ft.	Brass rod at 130 ft.				Screw stock at 40 ft.	Brass rod at 130 ft.
1/8	.005	.0045	1222	3972	1 1/4	.018	.010	122	397
3/16	.006	.0045	815	2648	1 1/2	.020	.010	102	331
1/4	.007	.006	611	1986	1 3/4	.022	.010	87	284
3/8	.0085	.006	407	1324	2	.024	.013	76	248
1/2	.0105	.008	306	993	2 1/4	.026	.013	68	220
5/8	.012	.008	245	795	2 1/2	.028	.013	61	199
3/4	.014	.008	204	662	2 3/4	.030	.013	56	181
1	.016	.010	153	497	3	.032	.013	51	165

TABLE 31.—REAMING FEEDS AND SPEEDS.

TAPS AND TAPPING

592. *Q.*—How many flutes have hand taps?

A.—Up to 1 3/4 in., 4 flutes; 1 7/8 in. to 2 3/4 in., 6 flutes; and 3 to 4 in., 8 flutes.

593. *Q.*—How many flutes have machine taps?

A.—Commonly, though not always, as follows: 3/16 to 5/16 in., 4 flutes; 3/8 to 2 1/4 in., 5 flutes; 2 3/4 to 3 in., 6 flutes, and 3 1/4 to 4 in., 7 flutes.

594. *Q.*—How many flutes have hob taps?

A.—Generally from 1/4 to 1/2 in., 6 flutes; 9/16 to 13/16 in., 8 flutes; 7/8 to 1 1/2 in., 10 flutes, and 1 5/8 to 2 in., 12 flutes.

595. *Q.*—How many flutes have taper pipe taps?

A.—Sizes of 1/8 to 1/2 in., 4 flutes; 3/4 in., 4 or 5; 1 to 1/2 in., 5; 2 in., 7; 2 1/2 in., 8; 3 in., 9; and 3 1/2 to 4 in., 11 flutes.

596. *Q.*—How are pipe tap sizes measured?

A.—The sizes are given to pipe taps from the size of the hole in pipe for which they are intended. That is, a 1/8-in. pipe tap is nearer 3/8 in. in actual size, and is used to tap holes into which pipe having a hole approximately 1/8 in. in diameter is screwed.

597. *Q.*—What is the standard number of threads for pipe taps?

A.—According to the Briggs system, a 1/8-in. pipe tap has 27 threads per inch; 1/4 and 3/8 in., 18 threads; 1/2 and 3/4, 14 threads; 1, 1 1/4, 1 1/2 and 2, 11 1/2 threads; and all above that size, 8 threads.

598. *Q.*—What taper has a pipe tap?

A.—The taper is 3/4 in. per foot.

599. *Q.*—What is the temper color to draw taps made of carbon steel?

A.—For ordinary purposes, a dark straw or brown, or to a temperature of 470 to 490 deg. F.

600. *Q.*—What lubricant is used when tapping various metals?

A.—Generally for machine steel the tap is flooded with lard oil; for brass a little lard oil or dry; for aluminum kerosene or soap water; cast iron, dry. This practice is not universal, however, as some factories use soap water for everything, even on cast iron, while others use lard oil on nearly everything, though as a rule lubricant used when tapping cast iron clogs the tap and causes the metal to glaze.

601. *Q.*—What will prevent hand taps breaking in the neck, just between the threads and the shank?

A.—Use a pair of hot tongs and holding the shank just back of the neck, draw it to a blue, letting the color just run nicely into the first two or three threads.

CHAPTER XVI

MILLING, SAWING AND GEAR CUTTING

602. *Q.*—What are common types of milling machines?

A.—Plain, universal, Lincoln, heavy, horizontal, vertical spindle, hand.

603. *Q.*—In a general way what are the characteristics of the above?

A.—The plain and universal millers are of the knee type, having a horizontal work table carried upon a knee which is vertically adjustable upon the column of the machine to bring the work to the cutters.

The Lincoln and the heavy horizontal millers are provided with work tables which do not admit of vertical adjustment, the cutter arbor being adjusted instead to suit the position of the work.

The vertical miller has a vertical spindle for carrying end and face mills, and is equipped with both longitudinal and rotary tables.

Hand millers are used extensively in the production of small parts in small arms factories, typewriter works, etc. The feed is usually by hand lever and light cuts are taken with rapidity, the rate of movement of the work to and from the cutters being dependent upon the speed of the operator.

604. *Q.*—Are there other types of millers?

A.—Yes, there are many other machines for accomplishing milling operations on various classes of work. Examples are bench millers; valve millers; keyseat millers; the spline miller; die millers; profilers, etc.

605. *Q.*—What is the nature of the profiler?

A.—It is usually equipped with two vertical spindles, one of which is fitted with a guide plug which is held in contact with a master form or guide on the table. This controls the movement of the work under the other spindle, which carries a cutter for machining the edge of the work to the same outline as the master or model.

606. *Q.*—What is the difference between a plain and a universal miller?

A.—The former has a table adapted to travel longitudinally in a path at right angles to the cutter spindle. The saddle in which it slides has also a cross movement parallel to the spindle.

The table of the universal machine, in addition to having the above movements, may be swivelled in the horizontal plane and set at any angle in this plane to the axis of the cutter arbor.

607. *Q.*—What advantage does this present?

A.—It enables work to be presented to the cutters at the desired angle for different operations, such as the cutting of helical gear teeth, the milling of spiral reamers, the fluting of twist drills, etc.

608. *Q.*—Is the spiral dividing head essential to such operations?

A.—Yes; this head holds the work and when geared to the table feed screw it gives the work a rotary movement in conjunction with the longitudinal motion derived directly from the travel of the table.

609. *Q.*—What is the spiral dividing head?

A.—It is an attachment for the miller table, with a work spindle which may be set at any angle in the vertical plane. It carries an indexing crank for rotating the spindle by hand and an index plate by which the spindle may be turned through a definite part of a revolution and held there during the cut. Thus in milling a 12-flute reamer the head will be set up for indexing the spindle to 1/12 of a revolution at each cut. When a spiral flute is to be milled the spindle of the dividing head is connected by gearing to the table screw so that the rotation of the work is secured automatically as already pointed out.

The ratio between the worm and wormwheel in the dividing head is 1 to 40, so that the index crank must be turned 40 times to revolve the work spindle through one complete turn. The dividing head is used extensively for gear cutting, for gashing wormwheels, and the like.

610. *Q.*—Is there more than one system of indexing on the dividing head?

A.—Yes: plain, compound and differential. There are other methods also, but in principle these are modifications of one of the above.

611. *Q.*—What is plain indexing?

A.—Indexing directly for a certain number of divisions by turning the regular index crank past a certain number of holes in one of the circles of the index plate. Thus, in indexing for ten divisions we turn the crank four times and can use any index plate we choose. For fifty divisions we have 40/50 or 4/5 of a turn as the distance the crank must be revolved for each division and multiplying $\frac{4}{5} \times \frac{4}{4}$ gives us $\frac{16}{20}$ or 16 holes in a 20 circle on the plate as the indexing movement for each cut.

612. *Q.*—What is compound indexing?

A.—In this system a series of holes are formed in the back of the regular index plate; but the spacing is different than for the circles on the face of the plate. A spring pin is secured in the head to enter these holes. Now, in operating the dividing head for some number which cannot be secured by plain indexing with any of the regular plates, it is possible to get the desired movement or a close approximation to it by the combined movement of the index plate past the back pin (the compound index pin) and the regular movement of the index crank around the index plate.

613. *Q.*—What is differential indexing?

A.—This is a simpler process than the compound method for indexing any number not obtainable by simple indexing. The index plate is geared to the spindle of the dividing head, and as the index crank is turned by hand the plate is automatically rotated either in the same direction or opposite the movement of the crank, so that a differential motion is maintained between the two, and in moving between any two holes on the plate the index crank actually travels through an angular distance either greater or less than it would if the index plate were fixed as in plain indexing, and the crank turned past the same number of holes.

With this method almost any number of divisions may be made in a piece of work, by obtaining by computation the necessary gears for connecting the dividing-head spindle and the index plate.

614. *Q.*—What is continuous milling?

A.—The process of milling parts mounted upon fixtures on a continuously revolving table which brings one piece after another under the vertical cutter spindle. As fast as one piece is finished and passes the cutter it is removed from its seat by the operator and replaced by a fresh piece.

615. *Q.*—What is reciprocating milling?

A.—With this process two fixtures are attached to the table. Work is placed in the right-hand one, say, and the feed started. While the piece is passing under the cutter the left-hand fixture is loaded. The table feed is then reversed, and during the milling of the piece in the left-hand fixture the finished work is removed from the fixture to the right and a second piece put into place ready for machining.

616. *Q.*—What is string milling?

A.—This consists in securing a long row of pieces to the table of the miller or to fixtures on the table, then milling the entire lot from end to end before stopping the table feed. In other words, the row of pieces are machined the same as if they constituted a single long piece of work. Sometimes special vise jaws are made to hold a large number of small parts for string milling, say for squaring or slotting a projecting end of each piece in the row.

617. *Q.*—What is the customary way of feeding milling machine work to the cutter?

A.—Feeding against the cut as in Fig. 68 where the arrows indicate the direction of rotation of the cutter and the travel of the work.

618. *Q.*—What is the objection to feeding *with* the cut?

A.—If we feed *with* the cut as in Fig. 69 there is a tendency for the cutter to jump into the work and draw it along, table and all, and break the cutter unless special means are taken to offset the effect of backlash and other freedom in the moving parts. It is contended by some mechanics that this is the better way to feed the work but the difficulty of keeping the work from jumping into the cutter and causing trouble has led to the almost universal practice of feeding *against* the cut.

619. *Q.*—Will a thin slotting saw work the more accurately running with the feed or against it?

A.—A thin saw has a tendency to "run" to one side or the other in operation, consequently, in rotating in the opposite direction to the feed, as shown in Fig. 68, it is guided by its own cut and is apt to run off more and more as the cut proceeds. If operated in the manner indicated in Fig. 69 its teeth strike the top of the work and it tends to cut itself free and to run more nearly along a straight line.

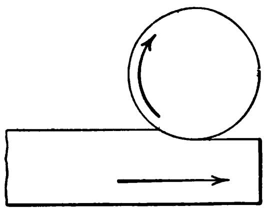


FIG. 68. FEEDING AGAINST THE CUT.

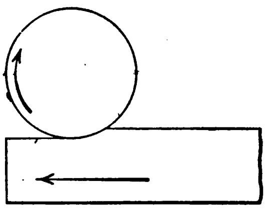


FIG. 69. FEEDING WITH THE CUT.

620. *Q.*—What is an automatic miller vise?

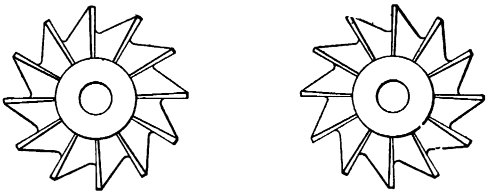
A.—This type of vise is frequently used on hand millers. Its movable jaw is usually pivoted and operated by a toggle lever. When the table with the vise is moved forward by the hand lever to carry the work under the cutter, the vise is automatically closed by the toggle action, and when the table is again drawn back, the vise opens to allow the work to be removed.

621. *Q.*—What are some of the common types of cutters?

A.—Angular cutters, for milling other cutters, spiral mills, etc.; convex and concave cutters, for milling half circles; corner rounding cutters for finishing edges of work; cotter mills, for cutting keyseats; dovetail cutters, for male and female dovetails and for beveling work edges; end mills, sometimes called butt mills, for machining slots, milling edges of parts, cutting corners and for many other operations; face cutters for surfacing work; formed cutters for milling a piece to any irregular outline; fluting cutters for cutting teeth on spiral mills, fluting taps, reamers, etc.; gang cutters, which are several cutters placed side by side on an arbor for milling a wide surface of any desired form; gear cutters, for all kinds of gear teeth; plain cutters, for milling plain flat surfaces; slotting cutters, for the slotting of screws and similar parts; straddle mills, a pair of side cutters used with a spacing collar between them, to mill work to specified width, or to cut slots at a definite distance apart; slabbing cutters, for milling broad surfaces, and usually made with spiral teeth which are often notched to break up the chip; slitting saws, or thin milling cutters, with the sides ground slightly concave to give proper clearance when cutting slots; stocking cutters, for roughing out gear teeth before running the regular gear cutter through; T-slot cutters, for milling the wide slot at the bottom of a T-slot to receive the head of a bolt.

622. *Q.*—What is a right-hand cutter?

A.—Fig. 70 shows both left- and right-hand mills. By examining the two it will be seen that if the right-hand cutter is held by the shank and viewed from the rear, it must cut when rotated to the right. That is, the miller spindle and cutter run right-handed if they rotate clockwise when the observer is standing at the rear.



LEFT-HAND MILL. RIGHT-HAND MILL.

FIG. 70.

623. *Q.*—How wide are plain milling cutters usually made with straight teeth?

A.—Up to about 3/4 in. When wider than this it is customary to cut the teeth on a spiral.

624. *Q.*—What angle of spiral is commonly used for the teeth of such a cutter?

A.—From 10 to 15 deg., depending upon the diameter and length of cutter. The idea is, of course, to give a free, shearing cut.

625. *Q.*—What are interlocking cutters?

A.—Side cutters are frequently made with the teeth of one cutter interlocking with or overlapping the teeth of the other. In using a pair of such cutters in milling grooves and channels, the cutters as they wear may be adjusted a definite distance apart to maintain an accurate overall width. The overlapping teeth prevent any gap between the two cutters and thus obviate the formation of a fin or rib in the middle of the surface which is being milled.

626. *Q.*—Are cutters of large diameter usually made solid?

A.—No, they are generally made with inserted blades or teeth so that a broken or worn-out tooth can be replaced without trouble.

627. *Q.*—What are some of the well-known inserted-tooth mill constructions?

A.—In one type, the teeth are held in their slots in the cutter body by means of binding bushings which are drawn down by screws into contact with the front face of the tooth. Another class of cutter has a taper pin hole reamed between every other pair of teeth, a slot is cut from the periphery of the cutter body through the taper hole and a taper pin driven in to expand the metal of the cutter body between the two teeth and thus bind them fast.

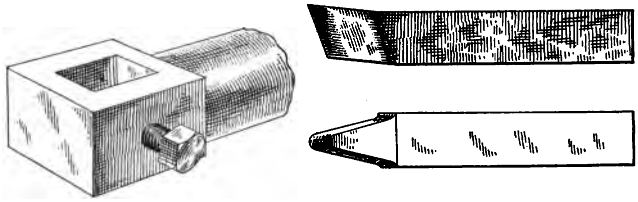


FIG. 71. FLY CUTTER AND ARBOR.

628. *Q.*—What is a fly cutter?

A.—A flat cutter filed or machined to the exact shape it is desired to reproduce upon a piece of work. The flat cutter is mounted crosswise in a slot in an arbor or holder in the miller spindle and the tool or other work to be machined is fed slowly past the revolving cutter. After roughing out the work in this manner the fly cutter may be held stationary like a planer tool and the work fed past it for a scraping, finishing cut. Such a cutter is shown in Fig. 71.

629. *Q.*—What is a fish-tail cutter?

A.—A flat-ended shank mill with a notched cutting edge which is formed as shown in Fig. 72. It is used for milling keyseats and grooves, and is usually operated at a high rate of speed and under a light feed.

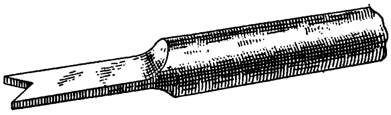


FIG. 72.—FISH-TAIL CUTTER.

630. *Q.*—What is the tendency in proportioning milling cutter teeth; are they becoming finer or coarser?

A.—Coarser. It has been found by experiment that coarse pitch mills cut more freely, require less power to operate, admit of a faster rate of feed and require sharpening less frequently than the finer pitch cutters.

631. *Q.*—What is the Brown & Sharpe system of involute gear cutters?

A.—In this system there are eight cutters regularly made for each pitch as given in Table 32.

No. 1 will cut wheels from 135 teeth to a rack.
No. 2 will cut wheels from 55 teeth to 134 teeth.
No. 3 will cut wheels from 35 teeth to 54 teeth.
No. 4 will cut wheels from 26 teeth to 34 teeth.
No. 5 will cut wheels from 21 teeth to 25 teeth.
No. 6 will cut wheels from 17 teeth to 20 teeth.
No. 7 will cut wheels from 14 teeth to 16 teeth.
No. 8 will cut wheels from 12 teeth to 13 teeth.

TABLE 32.—B. & S. SYSTEM OF INVOLUTE GEAR CUTTERS.

Such cutters are accurately formed and can be sharpened without changing their form.

632. *Q.*—What are duplex gear cutters?

A.—The Gould and Eberhardt duplex cutters are used in gangs of two or more to cut at once two or more gear teeth. Table 33 gives the number of cutters that may be used in cutting different numbers of teeth.

Under 30 teeth	1 cutter.
Over 30 teeth	2 cutters.
Over 50 teeth	3 cutters.
Over 70 teeth	4 cutters.
Over 95 teeth	5 cutters.
Over 120 teeth	6 cutters.
Over 150 teeth	7 cutters.
Over 180 teeth	8 cutters.
Over 230 teeth	10 cutters.
Over 260 teeth	12 cutters.

TABLE 33.—DUPLEX CUTTERS FOR CUTTING DIFFERENT NUMBERS OF TEETH.

633. *Q.*—What is a worm hob?

A.—In milling practice, a hob is a form of cutter with teeth arranged like a thread on a screw and with flutes to give the cutting edges. It is used for cutting the teeth of wormwheels to suit the worm which is to run with the gear.

634. *Q.*—Are worm hobs made the same size as the worm?

A.—No. The hob diameter should be the diameter of the worm plus twice the clearance which is allowed between the top of the worm thread and the bottom of the worm gear teeth.

635. *Q.*—How much clearance is allowed?

A.—Usually about one-tenth of the thickness of the tooth on the pitch line.

636. *Q.*—What does "gashing" mean in reference to worm gear cutting?

A.—The process of rough milling the teeth of the wheel at an angle closely approximating the helix angle of the hob and worm. This leaves little metal to be removed by the hobbing operation.

637. *Q.*—Are hobs used only for cutting worm wheels?

A.—No. Spur and spiral gears are now cut by the hobbing process.

638. *Q.*—How is this done?

A.—The hob is made of any convenient size, with the teeth corresponding to the pitch of the gear. For spur gears the hob is set at an angle to bring the teeth square with the gear blank. The hob feeds across the face of the gear and the gear revolves similarly to a worm gear. For spiral gear, the hob must be set to give the desired angle of tooth and the gear blank revolve at the proper rate. The details of the hobbing process require more space than can be given here.

639. *Q.*—What are the common types of metal sawing machines?

A.—The reciprocating power hack saw; the rotary cold saw; the metal band saw.

CHAPTER XVII

HAND AND AUTOMATIC SCREW MACHINE WORK

640. *Q.*—What are the general types of screw machines?

A.—Hand, semi-automatic, and automatic.

641. *Q.*—Into what classes may automatic screw machines be grouped?

A.—Single spindle, double spindle, and multiple spindle; the latter being made with 3, 4, and 5 spindles.

642. *Q.*—What is the difference between a screw machine and a turret lathe?

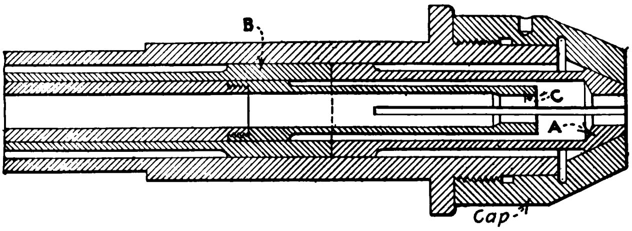


FIG. 73. SCREW MACHINE SPINDLE, NOSE, CHUCK AND FEED FINGER.

A.—A good many makers and users refer to the smaller sizes as screw machines and to the larger ones as turret machines or turret lathes. Others draw a distinction more by the nature of the work handled, thus classifying machines which machine bar stock as screw machines, and machines for castings and forgings as turret lathes or turret machines.

643. *Q.*—What is the difference between automatic and semi-automatic screw machines?

A.—In the former a bar of stock is placed in the spindle and the machine when once started continues its cycle of operations without hand control until the entire bar of material is used up. With the semi-automatic machine, a casting or forging is placed by hand in the chuck or in some special holder, and then the tool operations are carried on automatically until the piece is finished. It is then removed by hand and another piece put in its place ready for machining. Such machines are generally called turret machines or turret lathes instead of screw machines.

644. *Q.*—Are full automatic machines ever used in other than bar stock?

A.—Yes, the magazine automatic receives castings, forgings, and parts requiring second operations and feeds these pieces automatically to the spindle chuck without hand intervention. After the completion of each piece it is automatically expelled from the chuck and its place taken by the next blank in the magazine.

645. *Q.*—What is a spring collet?

A.—This is the spring chuck which holds the bar of stock in the spindle of the machine. A conventional type is shown at *A*, in Fig. 73. Usually such chucks are split at three points to allow them to be evenly closed on the work. The chuck is sprung open slightly before hardening and when pressed forward by the operating tube *B* in the spindle, it is closed by the taper in the cap and grips the stock tightly.

In some cases the taper on the chuck is made largest at the front end and the chuck is then drawn back into its seat to close it upon the stock.

646. *Q.*—What is a common form of feed finger?

A.—A feed finger, or feed chuck, as it is often called, is shown at *C*, Fig. 73. This is split at two points and is closed before hardening so that at all times it has a certain amount of grip on the stock. When the chuck is opened and the feed finger is fed forward it seizes the bar of stock and carries it through the chuck to the desired point, as determined by the feed cam itself or by a stock stop in the turret.

647. *Q.*—What is a convenient way of turning spring collets in the lathe?

A.—The blank may be roughed out first, then chucked out from the rear and taper reamed, so that it can be driven on a taper plug arbor fitted in the lathe spindle. The outer end of the collet can then be centered to allow it to be supported on the tail center and after the outside is turned to size, the gripping hole at the front may be bored to the right size to suit the stock to be handled, before removing from the arbor.

Two collets are sometimes roughed out end to end in one blank for convenience in handling and afterward cut apart and mounted on the taper plug arbor for finishing separately.

648. *Q.*—What procedure is necessary when the chuck must run absolutely true?

A.—In such cases the chuck must be ground after hardening and in order to grind the hole true, the chuck should be held in a machine fixture or quill which closes the chuck in exactly the same manner as it will be used afterward in the screw machine spindle. The hole is then finished with a small internal grinding appliance.

649. *Q.*—How can such collets be hardened without distortion?

A.—Sometimes in splitting the collet a thin web of metal is left at the mouth of the hole which serves as a tie to prevent springing and which is ground out after the chuck is hardened. Another method is to place thin strips of metal in the saw slots of the chuck (say 1/32 in. thicker than the width of the slot) and wire the nose of the chuck tightly to hold the steel pieces during the hardening process.

650. *Q.*—If a chuck runs out after hardening how may it be corrected?

A.—One of the prongs or jaws can be polished sufficiently to make it run true within at least 0.002 in.

651. *Q.*—Should feed fingers be bored to the exact size of the bar stock to be handled?

A.—No. They should be bored a little oversize, otherwise the corners of the chuck jaw will mar the surface of the stock when drawn back preliminary to the feeding movement.

652. *Q.*—What is a radial box tool?

A.—One in which the cutting tool is so placed as to be on the center line of the work. Such tools are quite commonly used in finishing operations.

653. *Q.*—What is a tangent box tool?

A.—One in which the cutter is inverted and placed to cut over the top of the work. Roughing box tools are commonly equipped with tangent cutters.

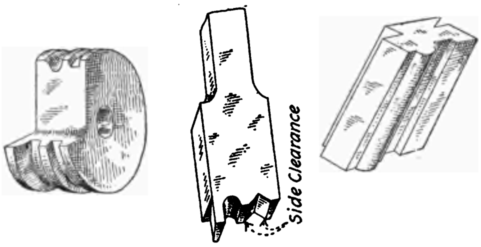


FIG. 74. FIG. 75. FIG. 76.

FORMING TOOLS.

654. *Q.*—What are the most common types of forming tools?

A.—Circular, flat and dovetail, shown respectively in Figs. 74, 75 and 76.

655. *Q.*—How is the clearance obtained on circular forming tools?

A.—By milling the cutter below center and then mounting it on a toolpost on the screw machine which is bored the corresponding amount above center, so that the cutting edge of the tool is on the exact center line of the work.

656. *Q.*—What is the usual amount of clearance on forming tools?

A.—Circular tools ordinarily have from 7 to 12 deg. peripheral clearance. Flat and dovetail tools are generally made with about 10 deg. front clearance.

657. *Q.*—What are some standard sizes of circular forming tools?

A.—The Pratt & Whitney sizes are given in Table 34:

No. 0 machine.	Outside diameter 1 3/4 in.	Cut 1/8 in. below center.
No. 1 machine.	Outside diameter 2 in.	Cut 3/16 in. below center.
No. 2 machine.	Outside diameter 2 1/8 in.	Cut 3/16 in. below center.
No. 3 machine.	Outside diameter 3 in.	Cut 3/16 in. below center.

TABLE 34.—PRATT & WHITNEY SIZES OF CIRCULAR FORMING TOOLS.

The Brown & Sharpe circular tool dimensions are given in Table 35:

No. 00 machine.	Outside diameter 1 3/4 in.	Cut 1/8 in. below center.
No. 0 machine.	Outside diameter 2 1/4 in.	Cut 5/32 in. below center.
No. 1 machine.	Outside diameter 2 1/2 in.	Cut 3/16 in. below center.
No. 2 machine.	Outside diameter 3 in.	Cut 1/4 in. below center.

TABLE 35.—BROWN & SHARPE CIRCULAR TOOL DIMENSIONS.

658. *Q.*—How can the circular tool be formed to correct shape at the distance below center where it is to be milled out for a cutting edge?

A.—After the tool has been finished close to size the master tool in the lathe toolpost can be dropped the specified distance below the spindle center and then fed into the circular tool to finish it exactly to shape. That is, if the circular tool is to be cut 3/16 in. below center for a working edge, the master tool for forming it is dropped for the finishing process 3/16 in. below the lathe centers.

659. *Q.*—How is the dovetail forming tool finished?

A.—The planer tool or shaper tool used as a master for planing the dovetail tool, should be set at the same angle in the toolpost as the dovetail tool will afterward be used on the work. This is illustrated in Fig. 77.

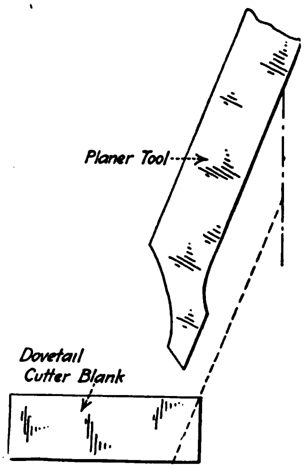


FIG. 77. DOVETAIL FORMING TOOL.

660. *Q.*—What is a fair amount to leave in screw machine practice for reaming?

A.—On steel work from 3/8 to 1 in. diameter of hole 0.004 to 0.008 in. is satisfactory, while in brass from 0.006 to 0.012 in. is a suitable allowance.

661. *Q.*—How should machine reamers be cleared?

A.—They should only cut on the front end when entering the work. Ordinarily they are cleared the full length of the cutting lips and have a back taper of about 0.004 in. per foot. The rose reamer is particularly useful for making smooth holes in steel in the screw machine. This reamer has no peripheral clearance but is back-tapered about 0.004 per foot.

662. *Q.*—How can taper reamers be prevented from pulling into the work?

A.—By cutting the flutes in the form of a left-hand spiral. Where the taper is slight this will obviate any drawing-in tendency which might otherwise break the reamer. Where the taper is steep, a right-hand flute may be used to assist the reamer in feeding in.

663. *Q.*—What number of flutes should be cut in straight chucking reamers?

A.—From 1/8 to 7/16 in. diameter 6 flutes.
From 1/2 to 1 1/4 in. diameter 8 flutes.
From 1 5/16 to 1 11/16 in. diameter 10 flutes.
From 1 3/4 to 2 3/16 in. diameter 12 flutes.
From 2 1/4 to 2 3/4 in. diameter 14 flutes.
From 2 13/16 to 3 in. diameter 16 flutes.

664. *Q.*—How should spring threading dies be tapped?

A.—The thread may be hobbed out with a hob tap 0.005 to 0.015 in. oversize and the prongs closed in use to proper cutting size by a clamp ring. Another way is to tap the die from the rear with a hob tap tapering from 3/16 to 1/4 in. per foot, leaving the front end about 0.002 in. oversize. A clamping ring is also used in this case. Both methods give suitable back clearance.

665. *Q.*—How should the cutting edge of a spring die be milled for use on brass?

A.—The cutting edge is generally radial for brass, and it may even be a slight amount below center to prevent digging in where the metal is free cutting.

666. *Q.*—What about spring dies for steel?

A.—On steel or other material which does not cut freely the die should have a positive cutting rake and therefore its cutting edges should be milled ahead of the center.

667. *Q.*—What is a button die?

A.—A die in the form of a thin disk, instead of with prongs as in the case of the spring die. It is usually split on one side and held in a ring holder which is fitted with a cone-pointed screw to adjust the die as required.

668. *Q.*—When the work spindle does not reverse, how are threading dies run on and off the piece?

A.—Either a self-opening die is used which can be withdrawn clear of the work as soon as the thread is cut and the die chasers are thrown open, or a threading spindle is employed for carrying a solid die, this being the case with certain multiple spindle machines.

669. *Q.*—How is the threading spindle operated?

A.—It is driven by gears and these are so proportioned that while the die which is carried at the right-hand end of the machine, is being run onto the work it is rotated in the same direction as the work, but at a slower speed. The difference in the speeds of the work and die spindles is the actual cutting speeds of the die. As soon as the thread is cut, a faster gear drive on the die spindle comes into action and the die is rotated at a faster rate than the work (though still in the same direction) and is thus withdrawn from the threaded piece.

670. *Q.*—Does the process of threading in this manner necessitate slowing down of the work spindles?

A.—No. In some multiple-spindle machines the work spindle opposite the die is stopped and the die run on by means of its gear-driven spindle. In another type of multiple-spindle machine the work spindles run constantly at uniform speed and the die is run on and off by the method described in the preceding paragraph. Thus, while the other bars of stock are operated on by the cutting tool at their regular speeds, the actual cutting speed of the threading operation is diminished.

671. *Q.*—What is a spotting drill?

A.—A short drill, either flat or twist, which is used for starting a hole in the end of the work. It is followed by a regular twist drill for putting the hole in to depth.

672. *Q.*—When should starting drills be used?

A.—When a long hole is to be drilled. And when the work projects some distance from the chuck the starting drill should be carried in a form of box tool which has a bushing for supporting the end of the work near the drill.

673. *Q.*—What should be the angle of the spotting drill point?

A.—It should be a little more acute than the point of the regular drill which is to follow, for this allows the outer diameter of the drill to cut before its blunt center web comes in contact with the piece. The point of the starting drill should be quite thin.

674. *Q.*—When is a straight flute drill preferable to the regular twist drill?

A.—Whenever the curling of the chips is troublesome, and particularly on brass work. The drill is made with two flutes and is sometimes known as a farmer drill.

675. *Q.*—What is a serrated drill?

A.—A drill with grooves cut across the lips to produce narrower chips.

Sometimes the serrations are milled along the side of the flute as well as on the point. Also the drill point can be formed in a series of steps for the same purpose.

676. *Q.*—What is good clearance for drills?

A.—From 0.007 to 0.015 in. per foot forms a good back clearance. The land back of the cutting edge should be narrow to prevent heating and sticking of chips to the drill surface.

677. *Q.*—Should the cutting edges of hollow mills be ahead of the center?

A.—Ordinarily they should be cut about one-tenth of the diameter ahead of the center. That is, a 1/2-in. mill would be cut 0.050 in. in advance of the center.

678. *Q.*—Is a free cutting rake on hollow mills always desirable?

A.—No. On automatic screw machine work, if the mill cuts too freely and curls up a long chip this causes more or less trouble, hence it is common practice on such work to do away with the rake to the cutting edge.

679. *Q.*—What is a recessing tool?

A.—This tool is made in various forms, but in all cases its purpose is to cut a chamber or internal groove at some point in the length of a hole. It enters the bore of the piece and is then swung out sidewise, usually by cross-slide mechanism, and the cutting point is then fed into the work. Upon completing the cutting of the annular recess, the tool is allowed to return to central position and is then withdrawn from the hole.

CHAPTER XVIII

GRINDING

680. *Q.*—How are grinding machines classified?

A.—They may be divided into the following groups: (1) Machines for grinding cylindrical and conical surfaces. (2) Machines for grinding plane surfaces. (3) Cutter tool and drill grinders for grinding milling cutters, reamers, lathe and planer tools and twist drills. While these machines are generally used for tool-sharpening purposes, in some cases they are also adapted for performing cylindrical and surface grinding operations. (4) Center and portable grinders for use in the tool post. (5) Bench, floor and swing frame grinders for general shop and foundry purposes; also for polishing and buffing.

681. *Q.*—What machines are included in group 1 for grinding cylindrical and conical surfaces?

A.—Plain and universal grinders; internal grinders; bench precision and traverse spindle grinders; miscellaneous grinders including machines for grinding crankshafts, camshafts, rolls, pulleys, car wheel, etc.

682. *Q.*—What are the grinding machines for producing plane surfaces?

A.—Horizontal surface grinders; vertical spindle surface grinders; end, edge or face grinders; disk grinders; belt grinders or grinder belts; piston ring grinders, etc.

683. *Q.*—What machines are in the cutter and tool-grinding group?

A.—Plane and universal cutter and reamer grinders; bench and floor grinders for planer and lathe tools; highly developed tool shaping and grinding machines where lathe and planer tools of all kinds are ground to definite angles of rake and clearance, the tool being held in an adjustable chuck by which angular settings are obtainable in all planes while the faces are ground by a wet wheel.

684. *Q.*—What are the usual types of tool-post and portable grinders?

A.—Center grinders for grinding lathe centers correctly while in place in the spindle; small electrical and belt-driven machines for mounting in the tool-post of the lathe, planer, shaper or miller for finishing all kinds of work where a regular cylindrical or surface grinder is not available. Such grinders are sometimes used on milling machines, rotary planers, etc., for sharpening the teeth of large cutters without removing the cutter head.

685. *Q.*—What are the general-purpose grinders in the machine shop and foundry?

A.—Bench and floor grinders usually with two wheels on the spindle and operated dry for grinding rough castings, forgings, and miscellaneous parts, removing fins and burrs from work rounding corners, etc.; swing frame grinders either suspended from over head or carried on a pair of wheels in such manner that the operator can pass the wheel at any desired angle over castings too large to handle on a fixed machine; portable grinders driven by flexible shaft and consisting of a wheel bracket with handles which enables the operator to apply the wheel to any part of a casting for removing rough surfaces, burrs, etc.

686. *Q.*—What is the difference between a plain and a universal grinder?

A.—The plain grinder is adapted for grinding cylindrical and taper work and is extensively used in the manufacture of such parts as rolls and shafts, machine spindles, columns, sleeves, bushings, etc.

The universal machine has a swivelling head stock and wheel stand and in addition to grinding the classes of work noted above, is adapted for grinding bevel and disk-shaped pieces across the face either at right angles to the axis or at any desired angle. It is also used in finishing internal surfaces, both straight and taper, and in some designs facilities are provided for grinding cutter and reamer teeth and for accomplishing certain surface grinding operations.

687. *Q.*—What is the traverse spindle grinder?

A.—This is an attachment for the bench lathe, and consists of a small high-speed wheel spindle which is slid to and fro in its bearings by the operator's fingers. It is used on very light, accurate work and it is necessary that the wheel should be given a very sensitive feed by pressure of the fingers at the sides of the small belt pulley or on a knob at the end of the wheel spindle.

688. *Q.*—What is the size and speed of the spindle in such a grinder?

A.—Usually the diameter of the spindle is about 1/2 in. and the speed about 12,000 r.p.m. Both the spindle and boxes are of hardened steel, ground and lapped for straightness and accuracy of fit. When properly fitted the spindle will run without oil, though usually in practice a couple of drops of watch oil may be applied to a small wad of paper or waste and rubbed onto the spindle while it is running.

689. *Q.*—What is the chucking grinder?

A.—This is a new machine designed for external and internal operations on various classes of cast-iron parts and on steel work, whether soft or hardened. It has three wheel spindles and the work when chucked is operated on by the wheels in the same advantageous manner as parts requiring turning and boring are machined in the turret lathe or chucking machine. Whatever the form of the piece may be, it is possible to bring one or more of the wheels to operate to advantage upon the work surface. This enables many parts, particularly such as are hardened, to be handled under especially advantageous conditions.

690. *Q.*—Name some of the commercial abrasives of which grinding wheels are composed?

A.—Emery, corundum, aloxite carborundum, alundum, crystolon, carbolite, carbondite.

691. *Q.*—Which of these are natural and which artificial?

A.—The first two, emery and corundum, are natural abrasives. The others are artificial products manufactured in the electric furnace.

692. *Q.*—What are the wheel-making processes?

A.—Wheels are made by three processes; vitrified, silicate (or semi-vitrified) and elastic.

693. *Q.*—What are these processes in brief?

A.—Vitrified wheels are made without tamping or pressing. The mixture of abrasive and bond is drawn off into forming rings, placed in drying rooms for some time, then reduced to approximate size and returned to the dry rooms to remain until thoroughly dried out. They are then placed in large kilns and subjected to temperatures of nearly 3000 deg. F., which causes the bond that holds the abrasive grains together to fuse and vitrify. This requires from six to ten days' time, depending on the size of the kiln. After leaving the kiln, the wheels are reduced to size and made to run true, they are then graded, tested and inspected.

Silicate wheels are made by the tamping process, the material being mixed mechanically and tamped in iron molds. The wheels are then dried and trued and from this point are treated the same as vitrified wheels.

Elastic wheels are bonded by gums and the mixture is heated and pressed in molds.

694. *Q.*—What are the bonds used with the different processes?

A.—The vitrified bond is made of fused clays, is unchanged by heat or cold, and can be made in a greater range of hardness than any other bond. It does not completely fill the space between the grains and the process makes an open-texture, free-cutting wheel. Such wheels are not affected by weather, time, oils, acids or soda, and are used for both wet and dry grinding.

The silicate bond is composed of clays fluxed by silicate of soda at low temperatures. Silicate wheels can be made of larger diameter and of greater thickness than is possible with the other processes. Such wheels are often made with a wire net to strengthen them, though some makers do not believe the net is essential.

The elastic bond is composed of shellac and other gums. It completely fills the void between the grains, has a high tensile strength and can be used for the making of very thin wheels.

695. *Q.*—How thin can elastic wheels be made?

A.—Such wheels are made as thin as 1/64 in. up to 2 in. diameter; 1/32 in. up to 4 in. diameter, 1/16 in. up to 10 in. diameter; 1/8 in. up to 12 in. diameter. A wheel of fine grit can be made thinner than one of coarse grit and have the same factor of safety. The minimum thickness depends then upon both the wheel diameter and the coarseness of the grit used.

696. *Q.*—What do the terms Grade and Grain mean?

A.—Wheels are made in various combinations of coarseness and hardness to meet the different conditions of service. The cutting material, the abrasive, is crushed and graded from coarse to fine in many sizes designated by number. Thus the sizes of grain used in the Norton wheels are numbered, 10, 12, 14, 16, 20, 24, 30, 36, 46, 50, 60, 70, 80, 90, 100, 120, 150, 180, 200. Finer grades known as flour are also used sometimes, these being known as *F*, *FF*, *FFF*, and so on. By No. 20 grain is meant the size that will pass through a grading sieve having twenty meshes to the linear inch.

The term grade refers to the degree of hardness of a wheel or the resistance of the cutting particles under grinding pressure. The grade of hardness depends principally upon the bonding material used. A wheel from which the cutting particles are easily broken, causing it to wear rapidly, is called soft, while one which retains its particles longer is called hard. Wheels are usually graded from soft to hard. Thus, in the Norton system the grade list starts with the letter "*E*," designating a soft wheel, and continues through the alphabet to "*Y*" which is extremely hard.

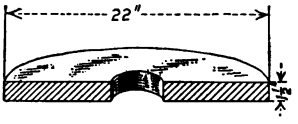


FIG. 78. DISK WHEEL.

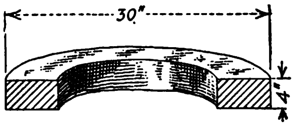


FIG. 79. RING WHEEL.

When we speak of a wheel as "No. 24*L*" we mean a wheel in which No. 24 grain is used and the degree of hardness is *L*, which in the Norton list is 1 deg. softer than medium.

697. *Q.*—What are the most common shapes of grinding wheels?

A.—The disk wheel, Fig. 78, which cuts on the edge; the ring wheel, Fig. 79 which also cuts on the edge; the cup wheel, Fig. 80 and cylinder wheel, Fig. 81, both of which cut on the end; the saucer wheel, Fig. 82, which cuts on the narrow side face at the outside of the wheel. All of these wheels are made in a variety of diameters and width of face.

698. *Q.*—What are the general uses of these types of wheels?

A.—The disk wheel is perhaps the most common of all. It is used on all kinds of bench and floor grinder stands and on many regular types of grinding machines.

The ring wheel is a modification of the regular disk wheel with enlarged opening at the center, which is mounted for use on a metal holder or center, which in turn fits the spindle of the machine. Such wheels are used where comparatively little reduction in the diameter is desirable and as soon as they have worn down a certain distance they are replaced by a new ring which is mounted on the old center or holder.

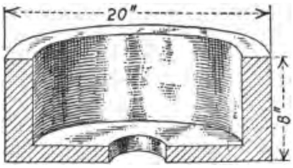


FIG. 80. CUP WHEEL.

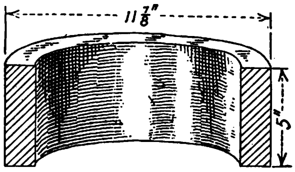


FIG. 81. CYLINDER WHEEL.

The cup wheel is used on a variety of machines where grinding is done on the end of the wheel instead of on the edge. Vertical surface grinders use a wheel of this general form, though somewhat modified in detail. Such wheels are also employed on knife grinding machines, and in smaller sizes on cutter and reamer grinders.

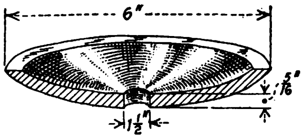


FIG. 82. SAUCER WHEEL.

The cylinder wheel is also for grinding on the end the same as the cup wheel. Such wheels are made in various sizes and used on vertical surface grinders, edge grinders, etc. They are held in ring chucks.

The saucer wheel is commonly employed on cutter and reamer grinders, the shape of the edge enabling it to be used in narrow flutes, and adapting it for a variety of cutter-sharpening operations.

699. *Q.*—What is one of the advantages of the cup and ring forms of wheels?

A.—Such wheels, cutting always on their ends, never change their diameters as they become worn, and thus it is possible to maintain a constant peripheral velocity of the wheel without altering the speed of the spindle.

700. *Q.*—What is a saw gummer?

A.—A small narrow wheel with rounded edge for grinding between the teeth of circular saws and grinding down in the gullet or concave space between the bottom of the teeth.

701. *Q.*—What is the usual speed of grinding wheels?

A.—The average circumferential speed is about 5000 ft. per minute. This is sometimes exceeded, 6000 ft. being not at all uncommon and even higher speeds have been used at times. Most makers, however, recommend a speed of about 5000 ft. in order to allow an ample margin of safety.

702. *Q.*—What points must be considered in determing the choice of wheel for a certain piece of work?

A.—The Carborundum company states that three considerations are as follows:

(1) The rapidity of grinding or cutting desired; (2) the total amount of work to be performed; (3) the finish to be produced.

These three elements are usually of value in the order given here. The speed of a wheel and all other operating conditions being the same, they are influenced as follows: (1) The rapidity of cutting is increased by using a coarser grit or a softer grade; (2) the total amount of work performed by a wheel is increased by using a finer grit or a harder grade; (3) the finish produced by a wheel is increased by using a finer grit together with a softer grade.

703. *Q.*—How is efficient cutting action attained?

A.—Efficient cutting of a wheel depends much upon the speed of the work. Revolving the wheel at the speed recommended by the maker is the first necessity, and if the wheel is found unsuitable after experimenting with various speeds it should be changed for a harder or softer wheel as the conditions indicate.

704. *Q.*—In this connection, how do we know when a wheel is to hard?

A.—If, after trying all reasonable work speeds, a wheel should burn the work, or refuse to cut without excessive pressure, or persistently glaze the surface of the work, it is too hard for that particular work and material and may safely be rejected.

705. *Q.*—When is a wheel too soft?

A.—If, after trying all reasonably reduced work speeds, a wheel should lose its size quickly and show all signs of rapid wear, it is too soft for that particular work and material and may be rejected.

706. *Q.*—What is a glazed wheel?

A.—A glazed wheel is one whose particles have become dull or worn down even with the bond, the latter being so hard that it does not wear away fast enough to allow spaces between the cutting particles or the cutting particles to escape when dulled. Continued work with a wheel that glazes increases the smoothness of the wheel face and decreases the cutting.

707. *Q.*—What is a loaded wheel?

A.—A loaded wheel is one whose face has particles of the metal being ground adhering to it; one in which the openings or pores of the wheel face have been filled up with metal, leaving no room for clearance. It is not necessary that all of the pores of the wheel be filled up or loaded to prevent the wheel from cutting. The presence of a number of these pieces of metal on the face of a wheel prevents it from cutting into the work and the loaded places will create heat.

708. *Q.*—What are the causes of loading and glazing of the wheel.

A.—A wheel loads when it is too hard or when it runs too slowly, and a wheel glazes when it is too hard or runs too fast.

709. *Q.*—Is it economical to dress wheels frequently?

A.—Yes, when the work is of such nature as to cause the wheel to run out of true, frequent dressing will save the wheel rather than waste it. For example, a wheel that ran out 1/32 in. after one hour's grinding, ran out 1/8 in. after two hours' grinding, requiring the dressing off of twice as much material as would have been necessary had the wheel been dressed twice in the two hours' time.

710. *Q.*—What is the difference between truing and dressing?

A.—Dressing is not *truing*, but sharpening the wheel, and a dresser should never be used on wheels that grind round work on centers. When truing wheels for round grinding, a diamond should be held in a rigid tool post on the table of the machine. Good work cannot be done on a wheel that has been "trued" by hand.

711. *Q.*—What are some points to observe in mounting and using grinding wheels?

A.—Never crowd a wheel on the spindle; the bushing should be about 0.005 in. over size to slide nicely onto the spindle and squarely against the inside flange.

Never mount a wheel without flanges which are properly relieved and of suitable proportions. The flanges should be at least one-half the diameter of the wheel and have a true bearing at the outer edge. The inner flange should be fixed on the spindle.

Do not screw up the nut too tightly; it should be set up only enough so that the flanges will hold the wheel firmly. Keep the bearings well oiled to avoid possibility of heating the spindle and bursting the wheel through expansion of its bushing.

Keep all rests adjusted close to the wheel so that work cannot be caught.

Avoid heavy pressure of the work on the wheel when grinding.

Keep the wheel true by dressing frequently.

Use wheel guards wherever possible.

712. *Q.*—In turning work, what is a suitable allowance to leave for grinding?

A.—The practice of different grinder manufacturers and users varies. Some experts advocate turning the work with a very coarse feed, leaving a surface something like a rough screw thread for grinding. The idea is that with such a surface it is easier to grind off a given amount of metal than where the turned surface has been produced with a fine feed, and that the total cost of the combined lathe and grinder work is less where the turning is rough and considerably oversize than when the piece is reduced closely to size in the lathe leaving but little to remove with the grinder wheel.

Others advocate turning to fairly close limits and leaving a reasonably smooth surface for the wheel to operate upon. The practice in this latter case would be to leave about 0.008 and 0.012 in. for grinding on work of ordinary length and of diameters from say 1/2 to 2 in.

713. *Q.*—What are disk grinders?

A.—These are machines with a horizontal spindle carrying usually two steel disks ranging, as a rule, from 12 to 48 in. diameter and from 1/2 to 1 in. in thickness. These disks carry cutting or abrasive disks which are cemented in place and form a flat grinding surface called a grinding circle. The grinding circles are covered with any abrasive desired, to suit the work to be ground. The work is placed on a table at side of the disk and its surface ground flat by pressure against the abrasive disk. The work should be moved across the face of the disk to prolong the life of the disk and to grind a perfectly flat surface. Disk grinders are also made with two disks at the center of the machine, one stationary, the other on a sliding head, so that work can be held between them on a suitable rest and ground on both sides at once.

714. *Q.*—What speed is generally employed in disk grinding?

A.—About 5300 ft. per minute is good practice for most work though for brass finishing a speed of about 6500 ft. is used.

715. *Q.*—What are strapping machines?

A.—The strapping machince consists of two flanged pulleys carrying a canvas belt loaded with glue and abrasive on the outer side. It has long been used for finishing irregular surfaces, especially on brass work. The straps or grinding belts run at from 2000 to 2500 ft. per minute in most cases.

A later development of this type of machine is the belt grinder, in which the belt is of emery cloth or other abrasive cloth cemented into an endless belt and run at about 7000 ft. per minute. At the point where grinding is done, the belt runs over a flat metal plate which supports both the belt and the work and produces remarkably flat surfaces; and accurate results are obtained in grinding such parts as collars and plates to a specified thickness. The belts usually run over or on top of a specially prepared leather belt which acts as a cushion.

716. *Q.*—What are the common polishing wheels?

A.—Wooden wheels, covered with leather; compressed wheels with steel center and having surfaces of leather, canvas or linen; canvas and muslin wheels; sea-horse wheels; felt wheels.

717. *Q.*—What are the uses of these wheels?

A.—At the present time the wooden, leather-covered wheel is used largely on flat surfaces and on work where it is necessary to maintain good edges.

The compressed wheel is used extensively in tool shops and also on cutlery and for polishing chilled plows.

Canvas and muslin wheels are used extensively for polishing stoves, shovels, plows, and for a variety of work in brass, cast iron and steel.

Sea-horse wheels are very expensive and most concerns buy the hides and make their own wheels. They are used for high-grade polishing such as is required on guns, pistols and cutlery.

Felt wheels are largely used by glove makers for finishing surfaces. They are made from white Spanish and Mexican felt.

718. *Q.*—What are a few of the points to observe in caring for wheels?

A.—Polishing wheels should be kept in perfect balance and running true at all times. A wheel out of balance wastes time, glue and abrasive, and will not do good work. The most efficient glue and the best abrasive are the cheapest in the long run. The glue should be properly cooked and the abrasive heated before applying. The wheels should be kept properly cleaned and thoroughly covered with the abrasive.

719. *Q.*—What are suitable speeds for buffing wheels?

A.—The following is considered good practice:

Wood, leather covered	7,000 ft. per minute.
Walrus	8,000 ft. per minute.
Rag wheels	7,000 ft. per minute.
Hair-brush wheels	12,000 ft. per minute.

720. *Q.*—What is the process of lapping?

A.—The finishing of work to a high degree of accuracy by means of flour abrasive and oil, or of diamond powder. Diamond laps are used extensively for grinding out very small holes and are usually of soft steel in which the diamond dust is imbedded by the charging process.

721. *Q.*—How are such laps charged?

A.—By hammering and by rolling. In the former process the lap is placed on a hardened block and the diamond mixed with a small quantity of oil to cause it to adhere is applied to the lap and struck light blows with a small hammer.

The smaller laps, from 0.010 to 0.040 diameter, are rolled between two plates, diamond powder being placed on the lower plate and carried to the upper by the lap in the act of rolling. Little pressure is required for charging the smaller sizes of laps.

CHAPTER XIX

PUNCHING, SHEARING, DRAWING, BENDING, AND STRAIGHTENING

722. *Q.*—How are templates made for dies of irregular outline which must be very accurate?

A.—To produce very accurate templates requires a high degree of skill but there is a little-known process devised by Ferdinand Alteneder, the instrument maker in Philadelphia, which simplifies the process considerably.

Make an outline drawing of the blank enlarged say 100 times. It is an easy matter for a good draftsman to get such a drawing accurate within say 0.01 in. Either rig up a camera or get a first-class map photographer to photograph the drawing, reducing it to correct size. This will give you a glass negative with a practically accurate image of the blank, because the errors in the original have been reduced 100 times.

A straight strip of steel is clamped to the negative and one edge of the template is made straight and slides on this. The tool maker can then shape the template and slide it up to the outline on the negative, taking care to hold it against the straight strip of steel. By holding the negative with the applied template to the light he can readily note where he has to file.

723. *Q.*—How is the steel for punches and dies prepared?

A.—This is rather a broad question, but with modifications the following will probably answer it:

The steel should be annealed very soft and of such size or thickness to allow about 1/8 in. to be machined off the outside, *i.e.*, the surface which has come in direct contact with the heat in annealing. Annealing decarbonizes the outside of the stock to a depth of 1/16 in., more or less, according to the size of the pieces and the way the work is done. If this decarbonized surface were allowed to remain and form a working (*i.e.*, cutting, etc.) part of the die or punch it would be impossible to harden it without recarbonizing by putting it through a case-hardening process. For this reason it is well to remove a sufficient amount so as to be sure that the die or punch will harden.

The working surfaces of both punch and die should be finished smooth. If these parts are finished while soft, on a surface grinder, it will leave a good surface for the copper fluid. This copper fluid is sulphate of copper dissolved in water with a few drops of sulphuric acid added. Another good solution which will leave the face of the work black is made and applied in the following manner: Mix 10 parts of water and 1 part of nitric acid; be sure to pour the acid slowly into the water and not the water into the acid. Wet the work with the solution and as soon as it is dark enough in color wipe or wash off the excess of acid. This will leave a surface on which scribed lines can be readily seen.

As a general thing it is better to make the die first when making press tools for sheet metal blanks because the die is apt to change its shape more in hardening than the punch. The template is applied to the coppered or blackened surface of the die blank and its outline carefully scribed, after which the metal is worked out and the die is hardened.

724. *Q.*—In hardening an intricate blanking die is there any way by which only certain parts can be hardened and other parts left soft?

A.—This may be done by what is called selective hardening. This is accomplished by exposing only those parts which are to be hardened and covering the other parts with a "fire paint." The following "fire paint" was given on page 450, Vol. 37, *American Machinist.* It consists of a mixture of 35 parts of pulverized hydrated potassium silicate (soluble potassium water glass) and 65 parts of pulverized dry sand. The ingredients must be very finely ground, mixed thoroughly and kept in a can with a tight-fitting cover.

When it is desired to use the fire paint, a small quantity of the powder is mixed with water to the consistency of a thin paste. The die is heated to about 300 deg. F. and the paint is applied with a small brush to those parts which are to be soft. The work is then placed on top of the furnace for a few minutes to dry, after which it is heated and hardened in the usual way. The coat of paint should be about 1/32 inch thick. After hardening the fire paint is readily removed by washing in warm water. Special forms of fire paint are also made regular commercial products.

725. *Q.*—How are punches laid off?

A.—As previously stated the die is made and tempered first. It can then be used as a template by placing it face down on the coppered punch face and scribing its outline thereon. A better way is to tin the face of the punch and float say 1/64 in. of soft solder on the tinned surface. When the punch is cool enough to handle set the die in the press in which it is to be used and the punch in the press ram. Throw the belt off the flywheel, trip the clutch and turn the flywheel by hand to bring the punch in contact with the die. The soft solder on the end of the punch will take an accurate impression of the die which can readily be followed by the diemaker.

726. *Q.*—Has sheet metal, steel, iron, brass, etc., a "grain"?

A.—Almost all sheet metals with the exception of copper, block tin, lead and some of the copper alloys known as "plating" or "platers" metal have a more or less defined grain which runs in the direction in which the metal was rolled. The effect of this grain is that metal which will readily bend across or at right angles to the grain will not bend to any extent without fracture parallel to the grain.

727. *Q.*—How many types of dies are there?

A.—Dies in general may be divided into two classes, the cutting and the shaping dies. Cutting dies include all dies which cut or punch work without changing the shape or form of the stock from its original plane. Shaping dies comprise all those which change the form of the stock from its original plane.

728. *Q.*—How many classes of cutting dies are there?

A.—Cutting dies may be divided into four types or classes; plain blanking dies, follow dies, gang dies and compound dies.

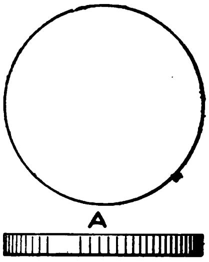


FIG. 83. EXAMPLE OF SIMPLE BLANKING DIE WORK.

729. *Q.*—Give an example of a blanking die and its work.

A.—At *A*, Fig. 83 is shown an example of the work produced from a plain blanking die. In this case the blank is round but it may be any shape, triangular, oval, square, etc. It is produced by a simple punch and die as shown in Fig. 84, in which *B* is the punch, *C* the die, *E* the stripper and *F* the opening for the stock to pass between the die face and the stripper. The end *G* of the punch is a snug sliding fit in the hole in the die *C*.

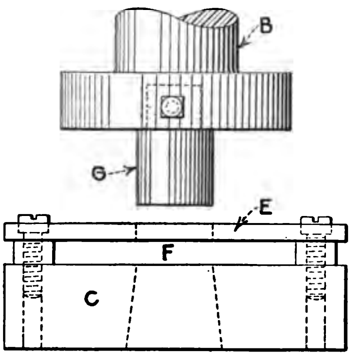


FIG. 84. SIMPLE PUNCH AND DIE.

730. *Q.*—What is the function of the stripper?

A.—The stripper, as shown in the example shown in Fig. 84, is to strip the perforated stock from the punch to which it has a tendency to cling.

731. *Q.*—Is a stripper ever used for stripping the work from the punch or die?

A.—Yes, a stripper is also used for this function and is known by a variety of names, viz., knock out, shedder, ejector, etc.

732. *Q.*—What is a follow die, and give an example of its work?

A.—A follow die is one in which two operations are performed, one after the other, by moving the stock along within the confines of the die, so that it can be pierced, slit, formed, bent, embossed, stamped, blanked, etc. An ordinary washer, shown in Fig. 85, is an example of work that can be produced on a follow die.

The stock is passed through the die in the direction of the arrow, Fig. 86. The first stroke of the press punches the hole in the washer. The stock is then passed along and the first washer is punched out while another hole is perforated at the same stroke.

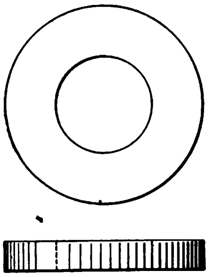


FIG. 85. EXAMPLE OF FOLLOW DIE WORK.

733. *Q.*—What is the difference between a follow die and a gang die?

A.—As previously stated the follow die has two or more stations where different operations are performed on the work simultaneously. The gang die has two or more stations where the same operation is performed on the work simultaneously.

734. *Q.*—Can you give an example of a gang die?

A.—Fig. 87 shows a gang die and its work. In this instance five holes are simultaneously punched in the work.

735. *Q.*—What is a compound die?

A.—A compound die is one which is so constructed that the upper and lower parts each contain a punch and die.

736. *Q.*—What is the objection to these dies?

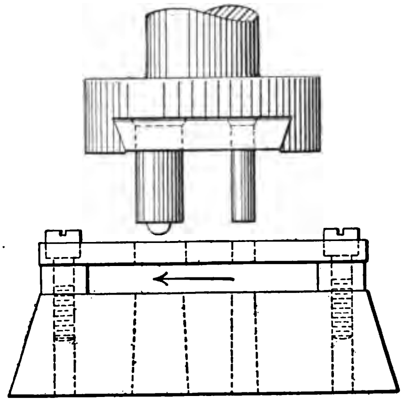


FIG. 86. FOLLOW DIE.

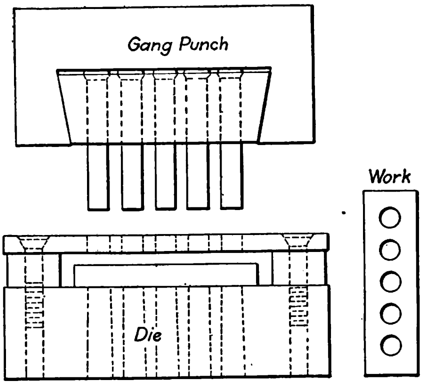


FIG. 87. GANG PUNCH AND DIE.

A.—They are as a rule very complicated in design and are apt to get out of order unless handled by an experienced operator.

737. *Q.*—What have they in their favor?

A.—They produce very accurate results because all operations are carried out at the same time, while the material is held firmly between the spring-supported surfaces.

738. *Q.*—What are perforating dies?

A.—Perforating tools consist of a number of piercing tools in one set of dies and may be called also multiple piercing tools. In the example shown in Fig. 88 which punches a larger number of holes in a disk, the work is held by the spring-controlled pressure-pad *A* against the face of the die *B* while the punches at *C* are forced down through the sheet metal. In this case the punches are easily replaced when broken, by unscrewing the holder from the shank and slipping the small punch out from the back.

739. *Q.*—In punching holes in soft steel plates, where the metal is rather thick in comparison to the diameter of the holes, is there any rule determining the thickness of metal which can be pierced by a punch of a given size?

A.—Soft steel is a somewhat elastic term, as soft steel varies considerably in hardness, but it ought to be possible under ordinary conditions to pierce soft steel equal in thickness to the diameter of the punch. With some grades of soft steel it is possible to pierce plates 1 1/2 times the diameter of the punch in thickness, but there will generally be excessive wear on the punch where the thickness is excessive, as compared to the diameter of the hole.

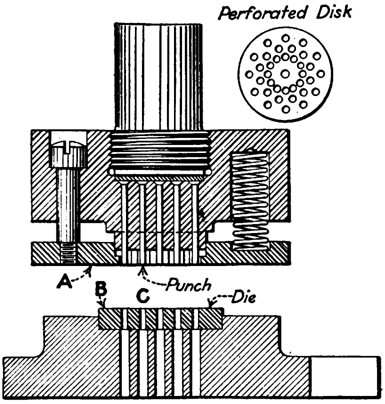


FIG. 88. PERFORATING DIES AND SAMPLE OF WORK.

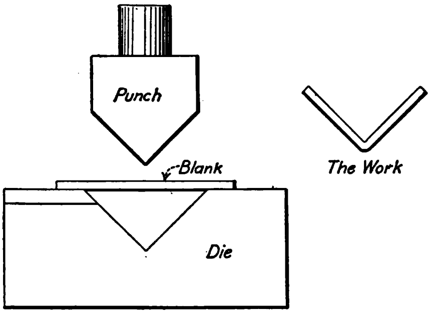


FIG. 89. A SIMPLE BENDING DIE AND ITS WORK.

740. *Q.*—What is a bending die?

A.—A bending die is one which is used for bending a peice of material usually metal. Simple dies of this character are usually made with the upper face of the die and the lower face of the punch to conform to the bend it is desired to give to the blank. An example of a simple bending die and its work is shown in Fig. 89.

741. *Q.*—In bending tubes as shown at *X*, Fig. 90, which are copper, 1/2 in. outside diameter, 1/16 in. thick and bent to one-fourth of a circle,

it is common to fill the tubes with lead, bending them in a fixture, melting the lead out and cutting the ends off. Is there a quicker and better way?

A.—This is a very simple job for the punch press. In Fig. 90 at *A* is shown the die, which is made in halves riveted together. *B* is the punch and *C* the work.

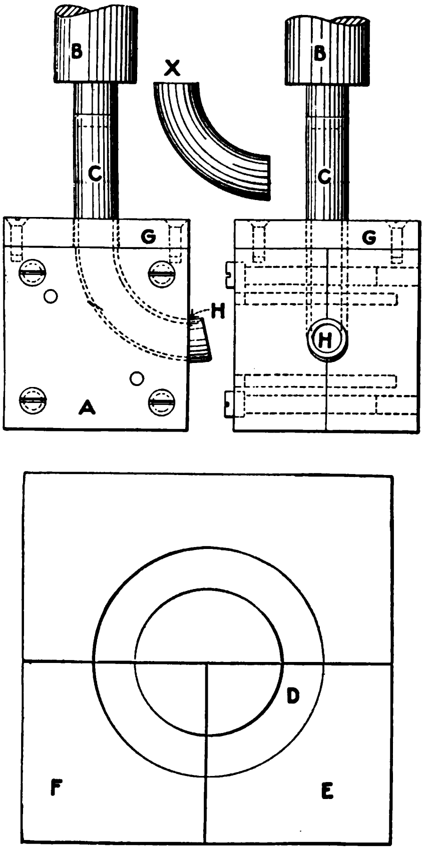


FIG. 90. PUNCH AND DIE FOR BENDING COPPER TUBES.

The lower cut shows how the die is made. A half round groove *D* is turned in a suitable piece of steel. Two saw cuts then produce the two quarters *E* and *F*, which are riveted together to form the die *A*. A piece of steel *G* with a 1/2-in. hole in it to accommodate the work *C* is then screwed to the top. This locates the work. The hole in the die should be slightly bell-mouthed at the top below the plate *G*, and it should be finished very smooth.

In action the punch *B* descends and pushes the first piece *C* down into the die *A*, leaving its top flush with the bottom of *G*. The punch *B* then returns to top position and another straight tube *C* is put into position in *G*. The press is tripped and the second tube forces the first one out at *H*.

There should be no difficulty in running the press at 40 or more strokes per minute. The tubes should be cut accurately to length and the die kept well lubricated.

742. *Q.*—What are heading dies used for?

A.—Heading dies strike up the heads on cartridges and other shells, and are generally operated in a horizontal heading machine.

743. *Q.*—What are index dies used for?

A.—For certain classes of work, such as notching the edges of large disks or armature punchings, an index die is sometimes used consisting of a rotary index plate adapted to carry the work step by step past the punches which cut out one notch or a series of notches at each stroke of the press.

744. *Q.*—What are piercing dies and what are they used for?

A.—Piercing tools are used for punching small holes through sheet metal. Where arranged for punching a large number of holes simultaneously they are often called perforating dies.

745. *Q.*—What are compound piercing dies?

A.—Compound piercing tools have, in addition to the regular punches carried by the holder in the ram, a set of horizontal punches for making holes through the sides of the work. These side punches are operated by slides moved inward by wedge-shaped fingers, the arrangement being the same as in the case of the compound bending dies, an illustration of which is given under that head.

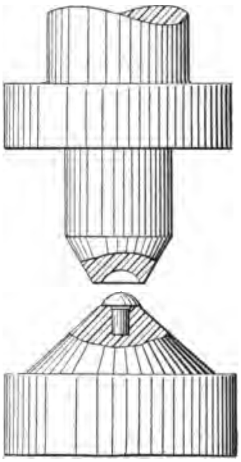


FIG. 91. RIVETING DIES.

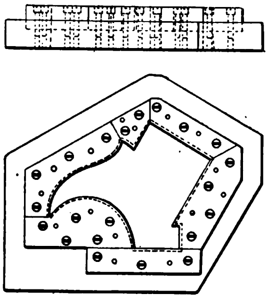


FIG. 92. SECTIONAL DIES.

746. *Q.*—What are reducing dies and for what are they used?

A.—Reducing dies are re-drawing dies for reducing a portion of the shell only, whereas the regular re-drawing die reduces the whole length. Reducing dies for cartridge shells form the familiar "bottle neck" shell now so commonly manufactured, with a large body for the powder and a smaller neck into which the bullet is secured. In dial feed presses ordinarily employed for cartridge-making operations, two or more reducing dies are often used for shaping the neck of the shell to the required dimensions, each die operating in turn upon the shell as it is carried around step by step under the press tools by the intermittent rotary movement of the feeding dial.

747. *Q.*—How are riveting dies for the punch press made?

A.—Riveting dies for the punch press are provided with cavities in the working faces to suit the shape of the head it is desired to produce on the ends of the rivets as shown in Fig. 91.

748. *Q.*—Why are sectional dies made?

A.—Frequently dies of complicated outline are built up in sections to enable them to be more easily constructed and kept in order. This form is resorted to often in the case of large dies where a break at one point would mean considerable expense for a new die. Also the difficulties of hardening are reduced with the sectional construction. As shown in Fig. 92 the various parts are secured to a common base or holder.

749. *Q.*—What are shearing dies used for?

A.—Shearing dies are used for cutting-off operations, and are frequently combined with other press tools so that after certain operations on a piece it can be severed from the end of the stock. The shearing tools shown in Fig. 93 are arranged for simply cutting up stock into pieces of the required length and the punch itself is of the inserted type secured by pins in its holder.

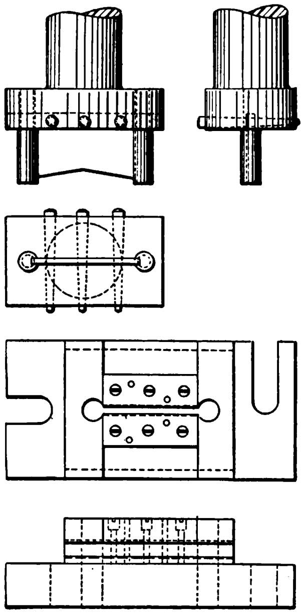


FIG. 93. SHEARING DIES.

750. *Q.*—What are split dies?

A.—Split dies form one type of sectional die—the simplest; they are made in halves to facilitate working out to shape, hardening, and economical maintainance.

751. *Q.*—What are sub-press dies?

A.—A sub-press and its tools are represented in Fig. 94. Such tools are used for small parts which have to be made accurately and are very common in watch and typewriter shops and similar places. The tools are held positively in line in this press and as a result their efficiency is maintained indefinitely. The press is slipped bodily into the regular power press with the base clamped to the press bed and the neck of the sub-press plunger connected with the ram of the press.

752. *Q.*—When are swaging dies used?

A.—Swaging operations are resorted to where it is desired to shape up or round over the edges of work already blanked out. Thus in watch-wheel work the arms and inside edges of the rims are sometimes swaged to a nicely rounded form subsequently to the blanking out of the wheel in the sub-press. Swaging dies for such work are of course made with shallow impressions which correspond to a split mold between the two halves of which the blank is properly shaped.

Bullet swaging dies receive the slug as it comes from the bullet mold and shape the end to the required cone point.

753. *Q.*—For what are trimming dies used?

A.—Trimming dies remove the superfluous metal left around the edges or ends of various classes of drawn and formed work. In the case shown in Fig. 95 the box body *A* has been drawn up and a fin left all the way round; this is dropped into the trimming die *B* and the punch *C* in carrying it through the die trims the edge off evenly, as indicated. Work of the nature shown in this illustration is blanked, drawn up and formed ready for trimming, by means of combination tools, a typical example of which will be found under the heading of combination die. The box body illustrated here as it

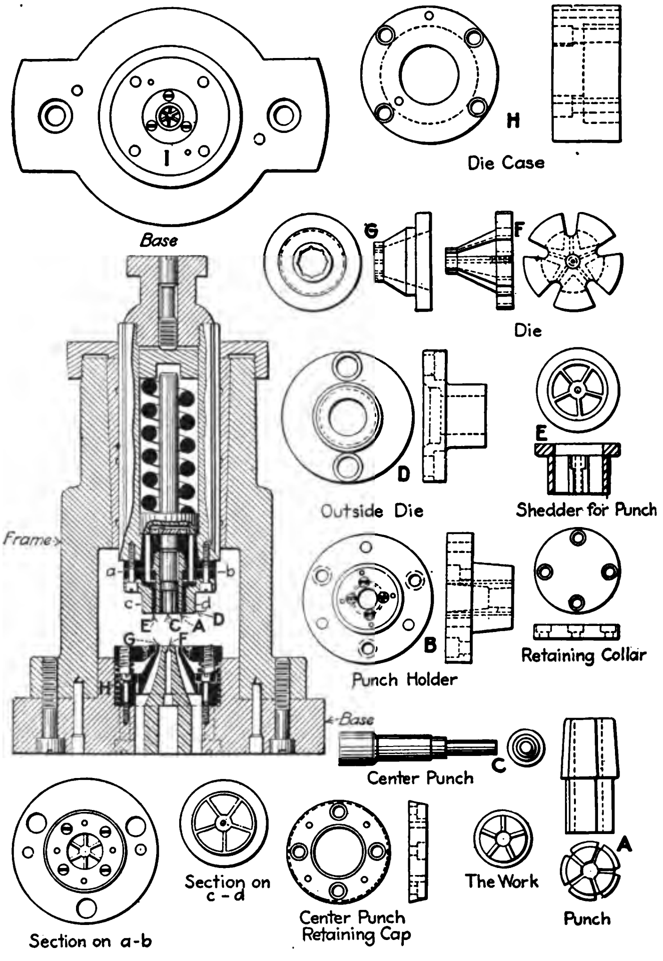


FIG. 94. SUB-PRESS DIES AND TOOLS.

appears before and after trimming is shown in connection with the combination dies as it appears in the blank, after it is formed, and after assembling with its cover.

754. *Q.*—How are triple-action dies used?

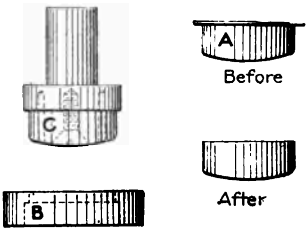


FIG. 95. TRIMMING DIES.

A.—These dies are used in triple-acting presses, where in addition to the double-action slides which take the place of the regular single-acting ram, there is also a third slide or plunger which operates under the table or die bed.

755. *Q.*—What are wiring dies?

A.—Wiring dies are much the same in construction as plain curling dies. In Fig. 96 the wire ring is shown at *A* around the top of the shell to be wired and in a channel at the top of the spring-supported ring *B*. As indicated in the lower illustration, the punch as it descends, depresses the ring *B* and curls the edge of the shell around the wire ring *A*.

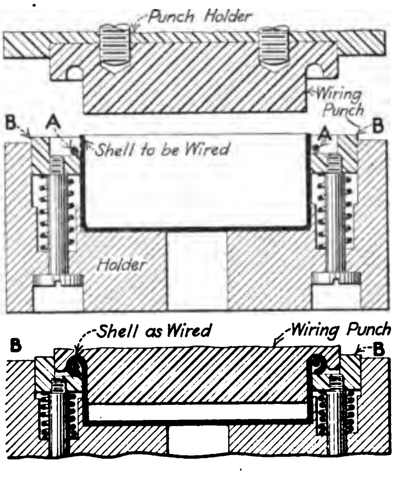


FIG. 96. WIRING DIES.

756. *Q.*—What are plain drawing dies?

A.—Dies of this type shown in Fig. 97 can be used for shallow drawing only, as there is no pressure on the blank to prevent its wrinkling when forced down into the die by the punch. The blank fits the recess *A* in the upper face of the die and the die itself which is slightly tapering is made the diameter of the punch plus twice the thickness of the wall required for the shell. The bottom edge *B* of the die strips the shell from the punch when the latter ascends.

757. *Q.*—What are re-drawing dies?

A.—Re-drawing dies are used for drawing out a shell or cup already formed from the sheet metal. In the illustration, Fig. 98, a shell ready for re-drawing is shown in position in the dies, which need little explanation. The work is located in the upper plate *A*, and after being forced through the die *B*, is stripped from the punch by edge *C*. Ordinarily, a shell which is to be given considerable elongation is passed through a number of re-drawing dies.

Re-drawing dies are sometimes referred to as reducing dies, although the latter, as explained under the proper heading are used for drawing down the end of a shell only, as in the case of a cartridge shell, which is made with a neck somewhat smaller in diameter than the body.

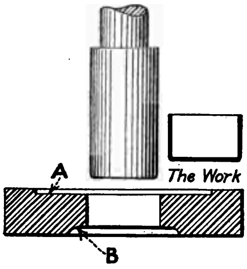


FIG. 97. PLAIN DRAWING DIES.

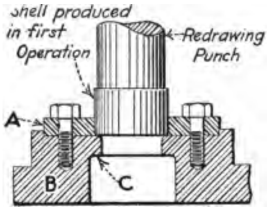


FIG. 98. RE-DRAWING DIES.

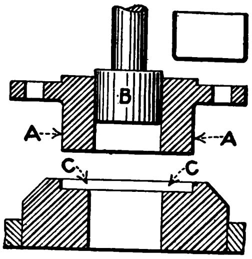


FIG. 99. DOUBLE-ACTION DIES.

758. *Q.*—What are double-action dies?

A.—This type of die shown in Fig. 99 is used in a press which has a double-acting ram; that is, there are two slides, one inside the other, which have different strokes. To the outer slide is fastened the combined cutting punch and blank holder *A*, which is operated slightly in advance of the drawing punch *B* actuated by the inner slide. The blank upon being cut from the

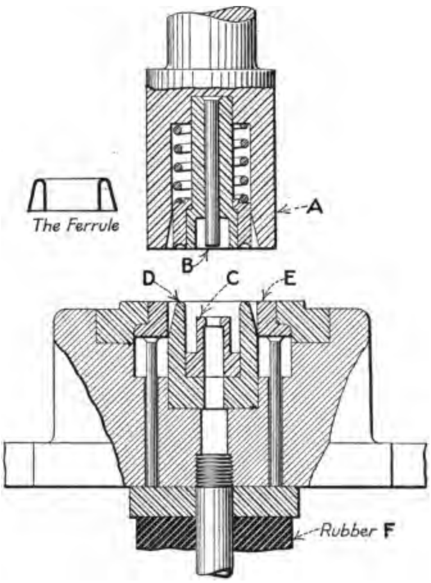


FIG. 100. COMPOUND DIES.

stock by *A*, drops into the top of the die at *C* and is kept under pressure by the flat end of cutting punch *A* to prevent its wrinkling, while punch *B* continues downward drawing the metal from between the pressure surfaces and into the shape required.

759. *Q.*—What are compound dies?

A.—Compound dies shown in Fig. 100 have a die in the upper punch and a punch in the lower die. The ferrule-making tools shown have a blanking and outer drawing punch *A*, with a central die *B*, to receive lower punch *C* which cuts out the center of the ferrule blank and allows the metal to be drawn down inside as well as outside of the bevel-edged member *D*. As the work is drawn down ring *E* descends compressing rubber cushion *F* below and upon the return movement the ferrule is ejected from the die.

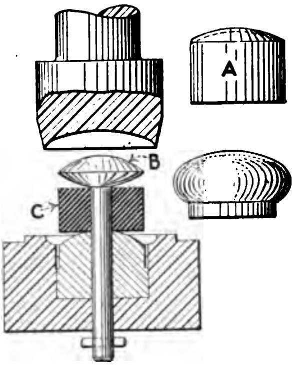


FIG. 101. BULGING DIE.

760. *Q.*—What are dinking dies?

A.—Dinking dies, or hollow cutters are adapted to punching out all sorts of shapes from leather, cloth, or paper. The edges of the dies are usually beveled about 20 deg. outside. As a surface for the cutting edge of the die to strike on, a block is built up of seasoned rock maple, set endwise of the grain.

761. *Q.*—What is a shaving die?

A.—A shaving die is one which is made of such size that when a previously cut blank is put in it, it is trimmed or shaved to exact size, either around its whole perimeter or parts of its perimeter.

762. *Q.*—Why is a shaving die used?

A.—To assure accuracy.

763. *Q.*—Is shaving always done in a subsequent operation after the blank has been cut?

A.—No, on some work shaving and blanking can take place simultaneously.

764. *Q.*—What is a bulging die?

A.—One form of bulging die is shown in Fig. 101 together with its work In this case it uses rubber to expand the work. The shell, after being drawn up straight as shown at *A* is placed over the mushroom plunger *B* in the bulging die and when the punch descends the rubber disk *C* is forced out, expanding the shell into the curved chamber formed by the punch and die. Upon the punch ascending, the rubber returns to its original form and the expanded or bulged work is removed.

765. *Q.*—What are squirting dies?

A.—Squirting dies are in reality swaging dies used for soft metals such as tin and lead and alloys of these two metals. They are used for making collapsible tubes for tooth paste, etc. The die is shallow and its diameter is the diameter of the desired collapsible tube. The punch is made long and the diameter of the inside of the tube. Both punch and dies as shown in Fig. 101 are finished very smooth. A soft metal blank is placed in the die and when the punch descends the tube squirts up around the punch.

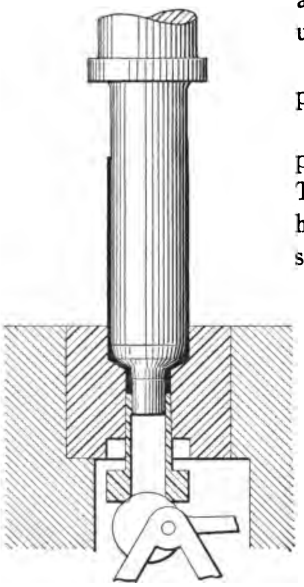


FIG. 101. SQUIRTING DIE.

766. *Q.*—How is the edge turned over on the piece shown in Fig. 102?

A.—The work referred to is done on the punch press and is called a curling operation. The work is first drawn in the shape of a hollow cylinder. The curling is done in a separate operation with a punch, in the ram of the press, shaped to make curl *A*. Sections of this punch are shown at *B*, with the work *A* in different stages. The punch *B* should be made very smooth so that the metal will follow the curve and slide readily. The curl should not be too large, as obviously the metal must first stretch on the edge to assume the large diameter and then compress as the edge approaches the body of the cylinder.

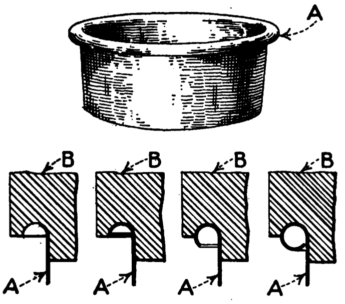


FIG. 102. CURLING OPERATION.

767. *Q.*—What are combination dies and what are they used for?

A.—Combination dies are used in single-acting presses for such work as cutting a blank and at the same stroke turning down the edge and drawing the piece into the required shape. In most cases the work is pushed out of the dies by the action of a spring. Such a set of dies is shown in Fig. 103, for making a box cover and body. The work is blanked by cutting-punch *A*, and formed to the right shape by *B* and *C*, the former holding the piece by spring pressure to the block *C* while punch *A*, continuing to descend, draws the box to the required shape. Ring *D* acts as an ejector or shedder and is pressed down, compressing the rubber at *E* during the drawing operation, and upon the up-stroke of the punch, ascends and ejects the work from the dies.

Dies of this type, with a spring actuated punch or die inside the regular blanking tool, are often used for simultaneously blanking and piercing, blanking and bending, etc.

768. *Q.*—Of what material are wire dies made?

A.—Chilled cast iron, high carbon tool steel, alloy steels, sapphires and diamonds.

769. *Q.*—How are the holes in the chilled iron dies made?

A.—The holes are cored. The cores used are steel rods with conical points around which the iron is cast. The holes in the chilled dies are consequently conical, say 1/2 or 5/8 in. on one side of a die 1 in. or so in thickness, and tapering to about 1/32 or 1/16 in. on the other side. The holes are reamed to size with square tapered reamers or broaches. These broaches are made of high carbon steel and are used dry. They are held in a chuck in a horizontal reaming machine and run slow. A 3/16-in. reamer would make from 40 to 60 turns a minute. The die is held in the operator's hands and tested from time to time with a plug gage for size.

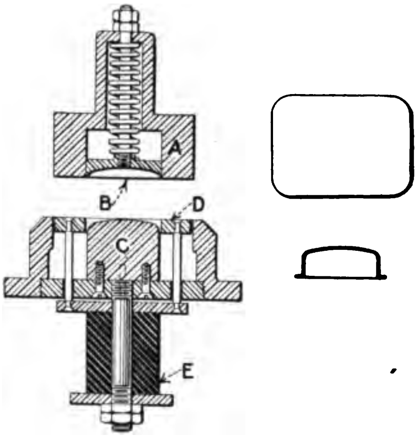


FIG. 103. COMBINATION DIES.

770. *Q.*—How are the holes in the alloy and high carbon steel dies made?

A.—The blocks are heated and punched while hot. As the punches are thin, in comparison to the work, they heat readily and the smith has a number of punches handy.

771. *Q.*—How are the holes made in the sapphires and diamonds?

A.—The stones (sapphires and diamonds) are flattened on one side by lapping. They are then cemented to a chuck in a small lathe. The operator takes a small splinter of diamond and holding this in a pair of plyers he turns a depression in the center of the stone on the side opposite the flatted surface.

The stone is next cemented to a chuck in a vertical automatic drilling machine, the flat side down and a small dam of beeswax around the turned depression in the top. This is filled with olive oil and diamond dust. The drill, which is mounted in a reciprocating spindle above the depression, is simply a sewing needle ground to the required size. The diamond dust imbeds itself in the steel needle and as it reciprocates up and down revolving at high speed, it gradually laps a hole in the sapphire or diamond.

When the hole is through the stone, it is mounted in a setting of brass and held in a chuck in the lathe. With a diamond charged needle the hole is lapped out to the desired size.

772. *Q.*—How does the diamond die maker measure the hole in the die he is making?

A.—From time to time as the work progresses he points a piece of brass wire, passes it through the hole in the die and draws it to the size of the die. He then measures the wire with a micrometer and in this way obtains the size.

773. *Q.*—How small can holes in diamond dies be made?

A.—As a rule about 0.001 in. is as small as is made, but dies with holes 0.0007 in. diameter have been made in this country.

774. *Q.*—Some wire 1/12000 in. can be bought. How is this wire drawn if the smallest dies are as large as stated in the previous answer?

A.—The wire referred to is platinum wire for use in scientific instruments, where it is used for cross hairs and takes the place of spider's web which is commonly used for this purpose.

The platinum wire is first passed through a series of dies till it is say 0.001 in. diameter. It is then electroplated with silver to a definite size. This silver wire with a platinum core is drawn through the various dies till it is say 0.001 in. diameter. The silver is then eaten off the outside by placing it in acid. This leaves the platinum wire of the desired size, as the acid used (nitric) does not attack platinum.

775. *Q.*—How near round are the holes in the dies, or in other words, how near round is commercial wire?

A.—The roundness of wire depends on the purposes for which it is to be used. The dies for drawing common pin wire are required to be within 0.0002 in. of round, not because any one would notice a greater difference than this in a pin, but because in pointing the pins they are rolled between disks, and wire which is much out of round will not roll, and the resulting pins would have chisel instead of conical points. Occasionally, one of these flat-pointed pins will be found in a paper of pins.

CHAPTER XX

SOLDERING, BRAZING AND WELDING

776. *Q.*—What is soldering?

A.—The process of uniting the surfaces or edges of the same or different metals by partial fusion.

777. *Q.*—How many kinds of soldering are there?

A.—Soldering may be divided into two classes, soft and hard soldering.

778. *Q.*—What is soft soldering?

A.—The method of uniting the same or different metals by means of soft, readily fused alloys applied to the surfaces of the pieces which are to be joined. These are prepared so that the solder, when fused, will adhere to the pieces and fasten them together.

779. *Q.*—How is a soldering iron prepared for soft soldering?

A.—The end while hot is cleaned either by filing, rubbing on stone or a piece of sal-ammoniac. Have a tin can lid or piece of tin with a depression hammered in it, in which there is a small piece of solder and some soldering fluid or paste. When the iron is clean and still hot, rub the end of it in the solder and soldering fluid. This operation is called "tinning" a soldering iron.

780.—How is soldering fluid made?

A.—Take some muriatic acid. Place it in a wide-mouthed earthenware or glass vessel, in the open air. Throw in some zinc clippings or filings. Be sure to add these slowly at first, as the acid will boil up, and if the vessel is shallow some of it may be lost. As the boiling action subsides, add more zinc till no more bubbles rise from the zinc. The clear soldering fluid can now be poured into a bottle, leaving behind the black residue from the zinc. For ordinary uses this is usually diluted with an equal amount of water.

A good soldering fluid for use on parts in danger of rusting is to take some of muriate of zinc, made as just described, and add from one to two parts of alcohol, in place of water.

781. *Q.*—How is tin soldered?

A.—The pieces to be soldered are fluxed with soldering fluid; placed as wanted, and the soldering iron at a black or dull red heat is held where the joint is desired, while a stick or wire of solder is held against the hot iron till enough runs into the joint. A little powdered rosin will also cause the solder to flow readily.

782. *Q.*—How is the surface of such metals as brass, copper and iron prepared for soft soldering?

A.—Cleanliness is of prime importance in all soldering operations. Clean the parts thoroughly by scraping, filing or with sandpaper or emery cloth. When quite clean cover the surface with soldering fluid or one of the soldering compounds which can be bought at any hardware store. Then heat the soldering iron and float a little solder over the surface. While the work is still hot enough to melt the solder, the excess of solder can be wiped off with a dry rag, leaving a thin film of solder. The pieces are then placed together and the hot soldering iron is applied. Sometimes a little extra solder may be required to make a solid job. This is readily run into the joint if the work is hot enough, as the solder has an affinity for such tinned surfaces.

783. *Q.*—How is cast iron soft soldered?

A.—Cast iron is supposed to be difficult to solder, but can be successfully accomplished in either of the following ways:

Clean the joints thoroughly, then scratch brush with a brass brush until the surfaces to be joined are covered with a coating of brass rubbed from the brush. Then tin and solder in the usual way. Or take a small quantity of mercury and amalgamate with it tin filings until it forms a plastic amalgam. Clean the surfaces to be soldered. Take a rag dampened with muriatic acid and rub a little of the amalgam on it. Rub this amalgam thoroughly into the metal at the joint; then solder in the usual way.

Often undiluted muriate of zinc will answer. Many times the trouble in making solder stick to cast iron is not in the flux, but in the fact that the casting is too large to heat readily, as the surface to be soldered or tinned must be heated considerably to make the solder stick.

784. *Q.*—Can you give me some soft solder formulas?

A.—The soft solder most used is 2 parts tin to 1 of lead. An easily fusible soft solder is made of 1 1/2 parts tin to 1 of lead. In Table 36 is given contents and melting-points of various tin-lead solders:

For plumber's work the solders from 4 to 8 are used with tallow as a flux. For lead and tin pipes No. 8 is used with a mixture of rosin and sweet oil as a flux. For Britannia Metal No. 8 is used with chloride of zinc (muriatic acid with zinc dissolved in it) or rosin as a flux.

785. Q.—How are the metals mixed when making solder?

A.—The tin is melted first in a porcelain or stone vessel, as when an iron ladle is used a certain amount of iron is absorbed by the solder. When the tin is completely melted the lead is added in small portions and thoroughly stirred with a stick of wood. The solder is then cast in suitable molds.

	Tin	Lead	Melting-point
1	1	25	558
2	1	10	541
3	1	5	511
4	1	3	482
5	1	2	441
6	1	1	370
7	1 1/2	1	334
8	2	1	340
9	4	1	356
10	4	1	365
11	5	1	378
12	6	1	380

TABLE 36.—CONTENTS AND MELTING POINTS OF TIN-LEAD SOLDERS.

786. Q.—What is hard soldering?

A.—Hard soldering or brazing is the joining of similar or dissimilar metals by means of hard solder, usually brass, which melts at a red heat.

787. Q.—How is work prepared for hard soldering?

A.—The joints are cleaned thoroughly and the parts fastened together either with wire, clamps or by pins. A little borax or boric-acid powder dampened with water is then put on the work at the joint. A little spelter (granulated brazing brass) can also be mixed with the borax. The job is now heated and borax and brass applied to the joint. When the brazing heat is reached the spelter melts and runs into the joint. The job is then allowed to cool till nearly at a black heat, when it is dipped in soapy water. This loosens the borax scale to a certain extent. If rubbed with a coarse file while still red hot the borax scale can be almost entirely removed. If boric acid is used instead of borax the scale is not difficult to remove.

788. Q.—What kind of fire is suitable for brazing?

A.—Brazing can be done well in any of the following ways: in a common forge, using soft coal, charcoal, coke or hard coal; the last is probably the best. The gas blowpipe is still better, and where the shape of the work will permit, the brazing brass can be melted in a crucible and the work dipped in it. This method is called "dip" brazing and is very satisfactory. Machines have also been made for brazing special jobs in large quantities by electricity. This last method is very good for brazing articles made of brass where the melting-points of the work and the brazing brass are very near each other, as the temperature can be regulated to a nicety.

789. Q.—How is cast iron brazed?

A.—The work is prepared in the usual way by cleaning the joints and securing the pieces so that they will not shift, plastic fireclay often being used for this purpose.

The compound used is made up of: 1 lb. boric acid, 4 oz. pulverized KCl (chlorate of potash) and 3 oz. carbonate of iron. This flux is used in connection with the brazing brass and applied liberally to the heated work. The work, however, should be brought to a red heat before the flux is applied.

790. Q.—What is a good formula for an ordinary brazing flux?

A.—Mix a pint of boiling water with 1 pint of borax, then add 2 pints of boric acid. This will make a thick smooth paste which is readily applied to the work and does not leave any scale.

791. Q.—What are some hard solder formulas?

A.—Table 37 gives some hard solders that have stood practical tests for various purposes:

	Copper	Zinc	Tin	Lead
Very refractory	57.94	42.06	....	....
Very refractory	58.33	41.67	....	....
Refractory	50.00	50.00	....	....
Readily fusible	33.34	66.66	....	....
Half white readily fusible	44.00	49.90	3.30	1.20
White	57.44	27.98	14.58	....
Malleable solder	72.00	18.00	4.00	....
Hard solder, according to Volk	53.30	46.70	....	....

TABLE 37.—MIXTURES FOR HARD SOLDERS.

792. Q.—How should the metals used in making hard solder be melted?

A.—The copper should be melted first and the other metals added, as the zinc is liable to "burn" out or volatilize if it is melted first.

793. Q.—What is welding?

A.—Welding is the sticking together of two pieces of metal while they are in a plastic condition. When iron is heated sufficiently it becomes fluid, but in passing from the solid to the fluid state it becomes plastic and at what is called a welding heat, about 2000 to 2200 deg. F., two or more pieces of it can be stuck together.

794. Q.—What is the principal practical difficulty encountered in welding?

A.—Oxidation, as the metal is liable to oxidize at a welding heat and the oxide or scale is not plastic like the metallic iron. For this reason welding only succeeds where this oxide is expelled from the contact surfaces of the pieces.

795. Q.—How is this difficulty overcome?

A.—By removing the scale formed while heating. This is effected by using one of the so-called welding powders, which in conjunction with the scale form slag which is readily expelled from the weld, providing the work has been prepared properly.

796. Q.—How should the work be prepared?

A.—This is a sweeping question and cannot be fully answered in the space available, but the preparation of two bar ends for welding will suffice for an example. The bars are upset on end to thicken them so that the subsequent hammering during and after welding, will bring them to size again. They are also scarfed, *i.e.*, tapered off on one side so that the two will match together, end to end. The surfaces where they meet should be somewhat rounded, so that when the welding is being done they will touch and stick in the center of the weld first and the scale and slag will be squeezed out as the two pieces are forced together by hammering.

797. *Q*.—What is the general procedure for welding?

A.—Take as an example, the joining of two rods end to end. The ends are prepared as stated in the previous question and are then put in a clean fire and brought *slowly* to near the welding heat. If they are short they can be taken out and the hot end dipped in welding powder; common sand or borax will do. If long or too large to handle readily the welding compound is sprinkled on the work where the weld is to be made. They are then replaced in the fire and brought to a welding heat. The smith takes one piece and the helper the other. They are quickly laid one on top of the other with the heated part on the anvil face. The smith strikes a few very light blows to stick the pieces together. The blows are heavier as the work progresses, and on large work the sledge or steam hammer is used after the pieces have begun to weld. But great care must be taken to make the initial hammer blows light. Do not finish the weld cold but reheat if necessary, and after completing anneal the whole piece.

798. *Q*.—Can steel be welded?

A.—Yes, but while iron welds at a white heat, steel welds at a bright red, and if brought to a white heat it is spoiled, *i.e.*, *burnt.*

799. *Q*.—What kind of a fire should be used for welding?

A.—Coke or "breeze" that is, coal well burnt and the cinders washed. This removes the sulphur to a great extent, and sulphur is not good where welding is to be done.

800. *Q*.—Can steel and iron be welded together?

A.—Yes, axes, hatchets and many other tools are made by welding steel to iron or mild steel, which is practically the same thing.

801. *Q.*—How is steel welded to iron?

A.—Every smith has his own pet method but the following method is given by an expert: Take 500 parts, by weight, of borax; 70 parts sal-ammoniac; 70 prussiate of potash; 35 clean unrusted iron filings. Pulverize these in a mortar and put them in a pot or crucible. Water is added until a thick paste results. The crucible is then put over a fire and the contents constantly stirred until it is very thick. The resulting mass is then cooled and pulverized, when it is ready for use. The steel and iron are heated as previously stated; the steel at a bright red heat and the iron nearly white hot, the compound having been sprinkled on both of them when at a dull red heat. They are taken out of the fire and with light blows of the hammer and stuck together, the force of the blows increasing as the work progresses.

802. *Q.*—What is electric welding, how is it done, and on what metals is it used?

A.—Electric welding was invented by Prof. Elihu Thomson. It will join any two pieces of the same metal or alloy ranging from the most refractory down to an alloy that fuses at 162 deg. F. It will also weld dissimilar metals when the welding point of one is not too far in excess of the fusion point of the other. In the electric welding process the two pieces to be joined are secured in firm end contact by a pair of adjustable copper clamps, which are placed upon the top of the apparatus. An electric current of large volume is passed through the pieces, and the contact between them being of less conductivity than the homogeneous metal, heating ensues at this place. As the junction is brought to the proper temperature by the gradual motion of the regulating lever, and as the metal softens, the clamps are pressed toward each other to insure a continuous metallic union across the piece. Theoretically, the weld should begin at the center and proceed radially toward the surface, as the temperature becomes greater than at the interior, but in practice the welding begins at the first point of contact. The heating is further increased by the fact that the resistance of the hot metal is greater than that of cold metal.

The electric currents used in this welding process sometimes reach 50,000 amperes, but with an electromotive force of half a volt, and therefore not capable of giving a shock to a person.

The operation of electric welding is one of the simplest of mechanical processes, requiring but little skill on the part of the operator in comparison with that exact training of hand and eye and long experience necessary for ordinary welding. The operator must understand the color of the proper welding heat of the metal under treatment, but this is readily learned.

The work is not manipulated during the process, except when it is desired to reduce the burr at the weld, and is at all times under observation, and its heat subject to entire control by means of a lever which graduates the strength of the current.

The dynamo generating the electricity is self-regulating and requires no attention except for lubrication.

There is no unnecessary waste of fuel, the heating being local, and does not extend far from the weld; cotton-covered wire 1/4 in. in diameter can be welded without searing the insulation over 3/4 in. from the weld.

The time for making a weld varies from a fraction of a second to several minutes, according to the work.

803. *Q.*—What is oxyacetylene welding and how is it done?

A.—This is also called autogenous welding and is in reality the melting together of the edges or surfaces of two pieces of similar or in some cases dissimilar metals. The apparatus used is a blowpipe supplied with acetylene gas generated from carbide of calcium decomposed by adding water and oxygen gas which is usually supplied to the welder in steel cylinders under pressure.

The pieces to be welded are usually prepared by beveling the edges so that there is a V-shaped gutter formed on the outside. With the aid of the blowpipe the work is heated and a stick of similar metal is melted into the V-shaped gutter. Very little oxide is formed and the joint is usually clean and free from scale. Owing to the very high temperature of the flame the metal is somewhat weakened at and near the weld.

This process is also much used for cutting metals such as boiler and armor plate. The kerf is very narrow, only 1/8 in. or less, and the heating is so localized that the metal on either side of the kerf is not injured.

804. *Q.*—What is the oxhydric method of welding?

A.—This method is practically the same as the oxyacetylene method except that hydrogen gas is substituted for acetylene. It was originally patented in Germany, where the owners used it for opening plugged blast-furnace tap holes. It is now considerably used in this country for the same purpose, and has cut tap holes through 4 ft. of solid metal. The reduction in time by this method as compared with the old method of doing the work is as hours to days.

The apparatus consists of a blowpipe with two nozzles. One of these supplies a mixture of oxygen and hydrogen while the other delivers pure oxygen only. The nozzle delivering the mixed gases preheats the work in advance of the oxygen nozzle which does the actual cutting or welding.

805. *Q.*—What is thermit welding and how is it done?

A.—It is welding by the the use of a reaction between powdered aluminum and iron oxide, which produces an enormous amount of heat, and is really a casting, or more properly, a fusing process. A mold is built around the parts to be welded and a special crucible containing aluminum, iron oxide and iron punchings or similar material, is set over the mold. The mixture is ignited by means of a magnesium ribbon, and when thoroughly fluid, the crucible is tapped and the contents allowed to run into the mold. Previous to igniting the thermit mixture the mold and parts to be welded are heated as hot as practicable with a large blowpipe using gas or oil, so that the molten thermit will not chill on contact with the metal.

CHAPTER XXI

MISCELLANEOUS SHOP PROCESSES

806. *Q.*—How is steel coppered?

A.—Steel should first be cleaned, being sure that all grease is removed. Take about a pound of clean water and dissolve in it about an ounce of sulphate of copper (blue vitriol). If the water is heated the sulphate will dissolve quicker. Add a few drops of sulphuric acid. With a small swab dipped in this solution wash the part to be coppered.

807. *Q.*—Why is sulphuric acid put in "copper water?"

A.—When no sulphuric acid is present, so-called basic salts are deposited when the "copper water" dries on the work. These leave streaks and prevent the copper from adhering to the steel.

808. *Q.*—How is the necessity of reheating steel obviated?

A.—By quenching in a bath of glycerine, 80 parts; salt, 5 parts; sal-ammoniac, 1 part; concentrated muriatic acid, 1/2 part; and water 10 parts.

809. *Q.*—Can steel be surface-blackened in the same way that it is coppered with "copper water?"

A.—A weak solution of nitric acid and water will blacken steel, providing it is clean, bright and free from grease.

810. *Q.*—How is zinc for templates blackened so that it will show scriber marks?

A.—A weak solution of nitric acid and water will blacken the surface of zinc, which is free from dirt and grease.

811. *Q.*—How is sal soda used in cleaning work?

A.—Sal soda should be mixed with water and kept near the boiling point. The goods to be cleaned, if small enough, should be placed in a wire basket and raised and lowered rapidly several times in the hot solution. Sal soda is also called carbonate of soda and washing soda.

812. *Q.*—How is caustic potash used in cleaning?

A.—Caustic potash and caustic soda are used in solution in hot water practically the same as sal soda is used. More care is necessary, however, as serious burns are liable to occur as a result of careless handling.

813. *Q.*—How are castings cleaned?

A.—Castings are cleaned by sand blast, hand brushing, tumbling in tumbling barrels, and pickling.

814. How is sand blasting done?

A.—Sharp sand is fed to a nozzle which is very similar to an atomizer nozzle. Low-pressure air, say from 10 to 20 lb. pressure, is also supplied to the nozzle and this throws the sharp sand against the castings removing all dirt and scale.

815. *Q.*—What objection, if any, is there to sand blasting?

A.—The only objection to sand blasting is that in removing dirt, etc., from the exterior it also exposes surface imperfections such as blow holes. This was formerly considered by some foundrymen quite an objection. It is probable that this has, however, done much to improve the quality of castings in general.

816. *Q.*—How are castings tumbled?

A.—They are put a few or many at a time in a rotating barrel. These are made of metal or wood depending on the work to be tumbled, and may be round or polygonal in section with a door or doors for the insertion and removal of the work. Hard cast-iron stars or jacks with sharp points, old broken up emery wheels and large quartz gravel, are put in the barrel along with the work. The power is then thrown on and the barrel and work rotate for a longer or shorter time depending on the size, shape and degree of tumbling necessary.

817. *Q.*—Is there any objection to tumbling?

A.—Yes, slender or fragile work, which might be readily broken should not be cleaned in this way.

818. *Q.*—How are castings pickled?

A.—Sulphuric acid and water are mixed and placed in a wooden vat. On one side of the vat is an inclined runway where the castings after pickling are placed so that the acid will drain back into the tank. The action of the acid is to loosen the sand and scale so that it is readily brushed off or removed with a hose.

819. *Q.*—What objection, if any, is there to pickling?

A.—The principal objection to pickling is that the acid tends to cause the castings to rust.

820. *Q.*—Are any other acids used for pickling?

A.—Nitric acid is used to a slight extent, but is poor practice, and also hydrofluoric acid.

821. *Q.*—For what is hydrofluoric acid used?

A.—It is used for pickling steel castings. These castings are made in quartz sand as a rule and owing to the high heat the sand becomes imbedded in the steel. Hydrofluoric acid attacks the sand and also the scale or oxide of iron on the outside of the castings.

822. *Q.*—If a casting is rusty when it comes from the foundry, is it a sign that it has been pickled?

A.—It is a sure sign that it has been rusted, but castings are often tumbled, and then squirted with a hose and allowed to rust so that they will appear as though pickled.

823. *Q.*—In some foundries sand-blasted castings are allowed to lie around the shop when in course of manufacture. In course of time they become rusty and are difficult to paint and finish properly. How can this rusting be prevented?

A.—A large concern in Pittsburgh dips every casting after sand blasting in thin asphalt paint. This dries almost immediately and the castings can lie around the shop indefinitely without rusting.

824. *Q.*—What is good practice in painting machines?

A.—What is considered good practice in one shop might be considered poor or too good practice in another. The castings should be clean, that is free from dirt, rust and grease. A ground coat of thin machinery paint should then be applied either with a brush or an atomizer, both inside and outside, and allowed to dry thoroughly. The outsides of the castings should be filled with any good machinery filler laid on with brush or spatula or both. When thoroughly dry the surface should be rubbed down with block pumice stone and water to level it. This is followed by one or two coats of "flat" (that is non-glossy) machinery paint. If very fine finish is desired these should also, when dry, be rubbed down but with *powdered* pummice on a cloth pad.

If the final finish is to be glossy a coat of hard machinery varnish is put on. Finally, don't attempt to mix machinery paints, as there are a number of standard machinery paints on the market which will give the desired results without experiment.

825. *Q.*—How is oil reclaimed from chips and waste?

A.—This is usually done in either a filter or a "whizzer" or centrifugal drier.

In the oil filter the action is the same as in water filter. The oily chips are put into a receptacle with a perforated bottom. The oil flows by gravity through the filtering medium and perforations to a receiver at the bottom. This in general is the action of an oil filter. Various expedients have been employed to hasten the filtering process. Heat in various ways has been applied to the chips to render the oil more fluid and cause it to filter more rapidly. Hot water and steam have been caused to flow through the chips and carry the oil, which is readily separated later from the water or condensed steam.

The whizzer or separator is a cylindrical receptacle with perforated sides mounted on a central spindle. It is enclosed in a casing which catches the oil when it is thrown out. The action of the whizzer is as follows: The inner perforated receptacle is filled with oily chips and the machine started up. The oil is thrown by centrifugal force through the perforations of the inner receptacle and striking the casing falls to the reservoir in the bottom of the machine. Usually the oil is filtered after passing through the whizzer.

826. *Q.*—What materials are used in oil filters?

A.—Mineral wool, steel wool, porous clay, gravel, sand, filter paper, charcoal, etc., etc.

827. *Q.*—How is waste reclaimed?

A.—If the waste is very oily it is first passed through the whizzer or an oily waste press where the bulk of the oil is removed. If there is still sufficient oil to be worth reclaiming the waste is boiled in clean water. This releases much of the oil which owing to its lower specific gravity rises to the top and is readily separated. Two or more washings in this manner are often necessary. The actual cleaning of the waste is merely a washing process with hot water, a little kerosene and an alkali, such as sal soda. The waste is finally passed through squeezer rolls, or the whizzer, and dried at moderate heat.

828. *Q.*—What material other than waste is used for cleaning? And why?

A.—Rags or towels are used exclusively in some shops because they wipe slightly rough surfaces much cleaner than can be done with waste owing to the fact that waste carries such a large amount of lint. There is also less loss in cleaning rags or towels than there is in cleaning waste as they come from the washing process.

829. *Q.*—How is gasolene used in cleaning?

A.—Gasolene is used as a wash to remove oil and grease and is a solvent for practically all the animal, vegetable and mineral oils. It is very volatile and the vapors are very inflammable, and under favorable conditions when mixed with air are highly explosive. For this reason great care should be exercised when using it for cleaning.

830. *Q.*—Is there anything which is safe to use that takes the place of gasolene for cleaning?

A.—Carbon tetrachloride is a solvent for almost all kinds of dirt and grease and is perfectly safe to use, as it will not burn.

831. *Q.*—What abrasives are used in the shop?

A.—Emery and corundum are the principal natural abrasives used in the shop.

832. *Q.*—What is meant by natural abrasive?

A.—Emery and corundum are called natural abrasives because they are used practically as found, except for crushing to the various degrees of fineness to suit the work.

833. *Q*.—What other abrasives are there in use?

A.—There are a large number of manufactured abrasives ranging in hardness from that of chalk to nearly the hardness of the diamond. They are known by various trade names, such as Vienna lime, carborundum, crystolon, aloxite, alundum, etc.

834. *Q*.—What are the softer abrasives used for?

A.—The softer abrasives are used principally for polishing for if there be any large particles present these will crush rather than cut in and scratch the surface of the work.

835. *Q*.—What is Bortz?

A.—Bortz is the name given to any diamond which is not a carbon or black diamond and is not good enough to use as a gem.

836. *Q*.—What is Bortz used for?

A.—For making diamond tools, for cutting hard metals and other substances; for making diamond dust for lapping and for making wire drawing dies.

837. *Q*.—What is black diamond?

A.—Black diamond or carbon as it is usually called, is a blackish-gray non crystalline diamond which is found in Brazil only. It is the hardest known substance being a little harder than the gem or crystalline diamond.

838. *Q*.—For what are black diamonds used?

A.—Black diamonds are used for practially the same purposes for which Bortz is used. Where a high degree of hardness is essential they have a slight advantage over Bortz. Their cost is very high as compared with that of Bortz, being almost equal to that of the gem diamond of fair grade.

839. *Q*.—How is diamond dust made and graded?

A.—Fragments of Bortz are pounded to a powder in a hard steel mortar. The depression in the mortar is cylindrical and has a hemispherical bottom. The hole should be say 5/8 to 3/4 in. diameter by 3 to 4 in. deep. The pestle is a fairly snug fit for the mortar and its end is hemispherical.

840. *Q*.—How is diamond dust graded?

A.—After the Bortz has been pounded to a fairly fine powder it is poured into a glass or other vessel containing olive oil. The dust and oil is thoroughly stirred and allowed to settle for say a minute. The oil is then poured off into a clean receptacle, thoroughly stirred and allowed to stand for a longer period of time, say five minutes for the suspended diamond dust to settle. The oil is again poured off and again allowed to settle for a still longer time, and so on. The dust remaining in the bottom of each vessel is then put into glass vials and labelled 5 minutes–20 minutes, etc., dust. This indicates its fineness as obviously the very fine dust will remain longer suspended in the oil than the coarse.

841. *Q.*—How is diamond dust applied to a lap?

A.—Rolling is probably the best method. After the lap is turned or planed some diamond dust is forced into its face with a hardened steel roller, using more or less pressure, depending on the grade of the dust and the material of which the lap is made.

842. *Q.*—What is good practice in distributing and handling reclaimed oil?

A.—The main storage tanks are contained in a concrete and brick vault built underground, one reservoir for new oil; two tanks for used oil. The tanks for new oil arranged to be filled from tank cars or from tank wagons or barrels. Throughout the shop departments are pumping stations. All pumps should be self-gaging and capable of being set to give from a pint to a gallon of oil per stroke. The distribution is directly from the used oil tank in the storage vault. When a fresh supply is needed for any machine, whatever is required is pumped into a pail, if it is a small amount, or into a tank, if a large amount. These tanks are mounted on wheels. This method does away with transporting oil on elevators and throughout the plant in general. This reduces waste and frees the aisles and elevators for other uses.

The oil is carried away from the machines on the work and chips. The work is drained and the chips are run through a centrifugal machine to reclaim this oil. It is then allowed to run back by gravity into large steam-heated setting tanks in the basement. These have a cone-shaped bottom allowing the sediment to settle. Here the oil is allowed to cool, after which it is heated to 220 deg. F. for the purpose of sterilization before being pumped into the supply tanks. This process cleans the oil and renders it sanitary and more pleasant for use.

The sediment should be removed from the tanks every few days by pumping out oil from the bottom. At frequent intervals the oil should be tested before it leaves the final one of the bank of settling tanks to determine its cleanness and clearness. This is done by running a thin sheet of the oil from a test tube over a piece of clean glass. The remaining impurities and sediments are at once detected.

The supply tanks themselves should be periodically drawn off and thoroughly cleaned. The method is to shut off one, clean it, and allow it to fill while oil is being used from the others. The new oil is run from the large storage tanks into the used oil tanks periodically for the purpose of "make-up" and to keep a supply up to the requirements of quality and quantity. The settling tanks should have sufficient capacity to handle all the used oil. One of the advantages of a system like this is the freeing of floor space in the shop from barrels, tanks, and the like. The storage tanks themselves being underground are out of the way and the space over them is available for trucking and the loading and unloading of material. The pumps are placed in corners, that is, in spaces which could not be used for setting producing machines. The settling tanks are the only part of the apparatus occupying any amount of shop space, and these are in the basement.

843. *Q.*—How is the pouring temperature of babbitt metal determined?

A.—The average run of babbitt metal is at correct pouring temperature when it will char a dry pine stick.

844. *Q.*—What are modern methods of storing bar stock?

A.—Where there is sufficient room, bar stock should be stored horizontally. The racks are made with a suitable number of uprights with cross bars. The uprights divide the stock sizes horizontally and the cross bars, vertically.

845. *Q.*—What is a common method of distinguishing between different grades or brands of steel in stock?

A.—When bar stock is received the ends of the bars should be painted a distinguishing color. Some storekeepers paint a stripe of the distinguishing color the entire length of the bar.

846. *Q.*—What is a common method of distinguishing between different brands of tool stock when it has been cut off and forged into tools?

A.—In many shops each brand of carbon and high-speed steel is given a designating mark. These marks are kept on record in the toolsmith's shop. The toolsmith has a steel stamp corresponding to each designating mark and stamps each tool near the rear end as soon as he cuts it from the bar.

847. *Q.*—Why is it necessary to mark the tools thus with a distinguishing mark?

A.—Each maker advocates a certain method of treatment for his steel, this being especially the case with the alloy steels. When tools are thus marked, the toolsmith can then know what particular treatment to give them when they are returned to him for redressing.

848. *Q.*—Is there any simple way of determining whether steel is carbon or alloy steel?

A.—The simplest method is the emery wheel test. Carbon steel when ground dry throws off bright yellow flashing sparks. Air hardening (mushet) and alloy steels have a reddish dull spark when ground dry their spark resembling somewhat that of cast iron.

849. *Q.*—How is the so-called government blue imparted to steel parts?

A.—Into a thick cast-iron melting pot put 9 parts by weight of nitre and 1 part black oxide of managanese. Raise the temperature till the mass melts and assumes a very dull red color. The work to be blued should be polished and free from grease. The higher the polish and cleaner the work before bluing the finer its appearance afterward.

The work may be held in tongs and immersed a piece at a time or may be put in carriers or baskets and immersed a number at a time.

The length of time necessary to blue a given piece varies with its size and the depth of color desired. When the work has reached the desired degree of blue it is removed from the compound and washed in clean water. Some operators merely chill the work to a temperature of about 200 degrees and then cool off in oil. This latter method is said to give a more permanent surface.

Great care must be exercised to prevent the fire from coming in contact with the nitre as this is very inflammable. In the government shops the practice is to hold the compound at a lower temperature than given above. The operator tests the temperature by throwing a little dry pine sawdust on the surface. When the compound is hot enough to char the sawdust and make it glow, it is considered to be at the correct working temperature.

850. *Q.*—How is rust removed from machine parts?

A.—The only satisfactory way to remove rust from parts which have become rusted is by mechanical means, that is, abrasives. Rust can be, however, to a certain extent removed by first soaking the parts in kerosene and then without removing the adhering kerosene boiling them in strong caustic potash or soda. This will remove the red rust but will leave the discoloration on the surface. This as previously stated, can only be removed by mechanical means.

851. *Q.*—How can small spots of rust be removed from some fine steel tools?

A.—To remove rust from the polished surfaces of fine tools requires judgment. One must know when it is better to leave the rust than to remove it. For work of this character an ordinary rubber ink eraser is good. A cork moistened with kerosene and dipped in flour, emery or powdered pumice stone will also give good results. There is also on the market a rubber in which emery is imbedded. This cuts the rust very rapidly but the accuracy of a tool is of more importance than its polish so do not use an abrasive where it will destroy accuracy.

CHAPTER XXII

AUTOMOBILE SHOP WORK

852. *Q.*—How many types of motors are used in automobiles?

A.—Two, known as 2 and 4-cycle.

853. *Q.*—What is the difference between 2 and 4-cycle motors?

A.—In a 2-cycle motor one explosion is planned to take place every revolution, and in a 4-cycle an explosion every two revolutions.

854. *Q.*—Besides this, in what other way are motors divided?

A.—Into air and water cooled. In the former the cylinders are provided with projections or fins to carry off the heat and in the latter, water is circulated in a jacket around the cylinder.

855. *Q.*—In a water-cooled motor, how is the water kept from boiling and generating steam in excess?

A.—By running it through a radiator to cool it.

856. *Q.*—What is a radiator?

A.—A series of thin tubes, usually made of copper, through which the water circulates and is cooled by the air that strikes the tubes.

857. *Q.*—Should the water in the cooling system be kept as cold as possible?

A.—No. Since the auto engine is a heat engine, it is desirable that it be as hot as permissible, in order that the heat may be utilized for work instead of passing into cold walls and wasted. It is well known that a cold engine generates but little power till it is warmed up.

858. *Q.*—What then should be the temperature of the water used?

A.—It should be kept as close to the boiling point of 212 deg. as possible, without actually boiling.

859. *Q.*—Is this water apt to freeze when the motor is idle in cold weather?

A.—Yes.

860. *Q.*—How may this be prevented?

A.—A non-freezing mixture of wood or denatured alcohol can be mixed as follows for different temperatures:

A 20 per cent. solution freezes at 10 above zero.
A 30 per cent. solution freezes at 5 below zero.
A 40 per cent. solution freezes at 20 below zero.
A 50 per cent. solution freezes at 55 below zero.

A solution of 70 per cent. water, 10 per cent. glycerine and 20 per cent. alcohol freezes at about 8 below zero.

Calcium chloride was formerly used but is not now recommended.

861. *Q.*—How many cylinders are used in an automobile?

A.—Almost any number from one up to eight. At present the more common are two, four and six. At one time a number of three-cylinder motors were built, but were not satisfactory. A few racing machines have also been built with more than eight cylinders.

862. *Q.*—Is it customary to cast multiple cylinders *en bloc*, that is, in one piece?

A.—Practice differs. Air-cooled cylinders are cast singly and then bolted to the crankcase. This is also the plan followed by many builders of motors of the water-cooled type; however, some makers use as many as six cylinders cast *en bloc*. A rather common practice is to cast cylinders in pairs and then bolt them to the crankcase, whether intended for two, four or six or more cylinder motors.

863. *Q.*—How are motor cylinders usually machined in a factory?

A.—They are generally milled on the bottoms of the flanges and other flat surfaces or bosses that need it, then the flange holes are usually drilled so as to be used as locating points for subsequent operations. Next, the cylinders are bored out on a boring machine, and the other holes are drilled and tapped in a drilling machine.

The castings are now allowed to season for some time, or else are annealed, to give the strains set up by the removal of metal, and the shrinkage strains, a chance to adjust themselves, after which the cylinders are ground and other parts that need to be accurate are finished.

The actual sequence of operations varies in different shops, and no set rule can be given, but the above is the practice in general, though in some cases the cylinders are finish reamed instead of being ground.

864. *Q.*—Why is finishing cylinders by grinding usually considered the better practice?

A.—Because a reamer is apt to crowd the thin places in a cylinder outward or spring away from the hard spots, leaving a bore that is lumpy and not true, which is not the case with a well-made grinder.

865. *Q.*—Are all cylinders ground straight?

A.—Some are tapered slightly, so as to make them smaller at the explosion end, the idea being to allow for the expansion by heat.

866. *Q.*—What is the average allowance between cylinder and piston?

A.—Practice varies considerably in this, being from 0.0005 to 0.0025 in. Sometimes 0.002 in. per inch of cylinder bore is allowed at the head end and 0.0005 in. at the opposite end, one size tapering into the other.

867. *Q.*—Are pistons finished by grinding?

A.—Sometimes, but many makers do not consider it necessary.

868. *Q.*—Are they annealed or seasoned between operations?

A.—It is the usual practice.

869. *Q.*—Should the pistons of multicylinder motors be the same weight, or "balanced"?

A.—Yes. If not the motor will pound when running at high speed.

870. *Q.*—What is the allowance between the width of piston rings and the grooves in the piston?

A.—About 0.001 in.

871. *Q.*—What metal is used for piston rings?

A.—Cast iron has been found to be the best.

872. *Q.*—Are piston rings finished all over?

A.—Those cut from cylindrical castings or "pots" usually are, though some firms do not machine the inside. Those cast individually, usually on the sides and outside only.

873. *Q.*—Why are piston rings turned eccentric?

A.—So that when split on the thin side, they will equalize the pressure on the cylinder walls.

874. *Q.*—Is there any other way of obtaining this result?

A.—Yes. Some concentric rings are machined all over, and then peened on the inside, the peening being heavier on the side opposite the split.

875. *Q.*—Is the inside of an eccentric ring ever hammered or peened?

A.—Sometimes, on the thick side, in order to give the ring additional stiffness or "spring."

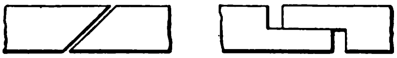


FIG. 104. SPLITTING PISTON RINGS.

876. *Q.*—How are the sides of piston rings usually finished?

A.—As a rule, by laying them on a magnetic chuck and grinding the sides, though some firms hold them one at a time on an expanding disk mandrel and finish the sides with a forked tool.

877. *Q.*—What is next done with them?

A.—They are split.

878. *Q.*—What two common methods of splitting are in use?

A.—As shown in Fig. 104.

879. *Q.*—After being split what is done with them?

A.—They are compressed so that the ends butt closely together, and held in a special flanged mandrel, as shown in Fig. 105 and the outside is ground or turned to size.

880. *Q.*—How are crank shafts machined?

A.—Either rough and finished turned and then ground, or rough and finish ground.

881. *Q.*—In grinding the crank pins of a multiple crankshaft, is it customary to use a wheel narrower than the surface to be ground, and to feed it back and forth?

A.—Formerly this was the only way, but now many firms use a wheel the width of the finished pin and feed it straight in, the face of the wheel of course being dressed so as to produce a straight pin with filleted corners. This method is claimed to be much quicker than the former.

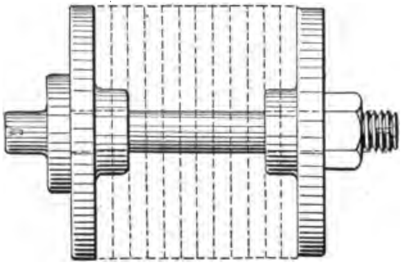


FIG. 105. COMPRESSING PISTON RINGS.

882. *Q.*—What other parts besides those already mentioned are ground?

A.—Camshafts, cams, gear holes and in many cases, valve stems.

883. *Q.*—Is it important to have the crankshaft and flywheel in perfect balance?

A.—Yes, or otherwise pounding will result, causing both noise and damage to the motor.

884. *Q.*—How are silent-running gears obtained?

A.—Aside from having accurately cut gears correctly placed on their shafts, the center distances of the shafts must be accurate.

885. *Q.*—How is this obtained?

A.—By using boring fixtures and afterward line-reaming with very accurate fixtures and tools. Some firms use dummy shafts, with disks on them in place of gears. These disks are the diameter of the gears at pitch line and the bearings in which the shafts are to run, are scraped till the peripheries of the disks will run in free contact, which insures the correct alignment of shafts and gears.

886. *Q.*—What shape are the seats of the poppet valves of a motor?

A.—Flat, or cone shaped, with an angle of 40 to 45 deg.

887. *Q.*—How are valve seats finished?

A.—They are machined so as to coincide as closely as possible, and then they are ground so as to be gas tight, by placing a mixture of oil and glass or fine emery under the valve and turning it back and forth.

888. *Q.*—What is the rule for the spring pressure on the intake and exhaust valve?

A.—The minimum pressure must be such, that the exhaust valve will not open during the suction stroke when the throttle is nearly closed.

889. *Q.*—What rule is used for the settling of the front wheels of an automobile, that is, what incline should be given them?

A.—Since the idea is to make steering easier and to not strain the parts any more than necessary, the front wheels should flare outward at the top, enough to bring the points at which they strike the ground, near to the points where lines drawn through the steering knuckle pins would strike the ground. These points should not exactly coincide, as the turning of a corner has a tendency to force or spring the bottom of the forward wheel inward. The general practice is to incline the wheels about 2 deg. with the vertical. The forward parts of the wheels are pulled inward enough to balance any tendency of the parts to spring, as the wheels should be exactly parallel when everything is right. Various conditions make it advisable to pull the wheels inward in front 1/4 in. or more, the looseness or spring of the steering parts governing this.

890. *Q.*—What rule governs the setting of the arms of the steering knuckles?

A.—An approximate rule is to draw lines from the middle of the rear axle through the knuckle pins and set the arms parallel to these. This is seldom needed, though, as in repair work the only thing necessary is to set the front wheels according to the foregoing rules, with the knuckle arms bent alike.

891. *Q.*—What is the A. L. A. M. standard horse-power formula?

A.—

$$\frac{\text{Bore of cylinder}^2 \times \text{No. of cylinders}}{2.5}$$

CHAPTER XXIII

RAILROAD SHOP WORK

892. *Q.*—What is steam?

A.—It is water changed by heat into a gas.

893. *Q.*—How hot does water need to be heated in an open vessel, at ordinary atmosphere, to boil?

A.—212 deg. in the open air and at sea level.

894. *Q.*—Can this temperature be increased by applying more heat?

A.—Not in the open air. More heat will cause more rapid boiling, but will not raise the temperature of the water above 212 deg., as the temperature will remain constant till the water is all evaporated.

895. *Q.*—How then can the temperature of the water be raised?

A.—By confining the water and steam in a closed vessel of some kind.

896. *Q.*—What pressure does the atmosphere exert?

A.—About 15 lb., 14.7 lb. at sea level.

897. *Q.*—Is this pressure included in steam-pressure calculations?

A.—Not ordinarily. The pounds pressure of steam means the number of pounds that pressure would lift per square inch, against the pressure of the atmosphere. This is called effective pressure. Where the 15 lb. per square inch of atmospheric pressure is included, it is known as absolute pressure.

898. *Q.*—What is the proportion between the volume of steam and that of the water from which it is formed?

A.—At the atmospheric pressure of 15 lb. per square inch each cubic inch of water will make 1610 cu. in. of steam. At double the pressure, or 30 lb., absolute pressure, it will make a little more than half as much, or 838 cu. in. and so on.

899. *Q.*—How much water is it necessary to evaporate in order to furnish the steam required to run an ordinary train at its usual speed?

A.—A Pennsylvania Consolidation locomotive weighing 194,000 lb., with cylinders 22 in. in diameter, 28-in. stroke, evaporated under various tests from 24,069 to 75,575 lb. of water per hour.

900. *Q.*—How much water will a pound of coal evaporate in ordinary practice?

A.—This varies with the quality of coal and the design and condition of the boiler, but 8 lb. per pound of coal may be taken as the average.

901. *Q.*—How can the strain on the flat surface of a boiler between the stay-bolts be calculated?

A.—By multiplying the area in inches between adjacent stay-bolts, by the pressure. With stay-bolts spread 4 in. apart and a steam pressure of 150 lb., the calculation would be $4 \times 4 \times 150 = 2400$ lb. on each bolt.

902. *Q.*—What pressure may be put on a stay-bolt?

A.—Never more than 1/10 or 1/12 of their breaking strength.

903. *Q.*—What is the tensile strength of ordinary stay-bolts?

A.—It should be between 46,000 and 53,000 lb. If outside of these figures most users will reject them.

904. *Q.*—How do stay-bolts in a boiler often fail, without breaking?

A.—By tearing or stripping the thread of the bolt, or that in the plate, or by the stretching of the heated plate under pressure, allowing the bolt to be pulled out.

905. *Q.*—Why are boiler flues arranged in vertical rows and not staggered?

A.—Because water will circulate easier between the flues, when arranged vertically.

906. *Q.*—How can the strain on the cylindrical part of a boiler be calculated?

A.—Diameter in inches times length times steam pressure per square inch.

907. *Q.*—How much strain per square inch is good boiler plate capable of resisting, and how much is it safe to subject it to?

A.—There is considerable difference in the strength of boiler plate, but good plate will average about 50,000 lb. per square inch if the strain is applied in the direction of the grain, and about 10 per cent. less crosswise. The strain, to be safe, should never exceed the elastic limit.

908. *Q.*—What are the important qualities which boiler plate should possess?

A.—Toughness, ductility, great tenacity, closeness and uniformity of texture, and evenness.

909. *Q.*—What is the strength of riveted seams, as compared with the solid plate?

A.—This depends on the proportion and arrangement of the rivets, but with the best construction the strength is always considerably less.

910. *Q.*—What are the usual proportions for single riveted, lap seams?

A.—Table 38 taken from Forney's Catechism of the locomotive gives these.

911. *Q.*—Is the maximum strength of seams the chief aim in designing a boiler?

A.—No. A tight joint is essential, for should leakage occur, corrosion will soon alter the conditions to the detriment of the strength.

Iron plates, iron rivets			Steel plates, iron rivets		
Thickness of plates	[1]Diameter of rivets	Pitch of rivets	Thickness of plates	[1]Diameter of rivets	Pitch of rivets
5/16 in.	11/16 in.	1 13/16 in.	5/16 in.	11/16 in.	1 9/16 in.
3/8 in.	3/4 in.	1 7/8 in.	3/8 in.	3/4 in.	1 9/16 in.
7/16 in.	13/16 in.	1 15/16 in.	7/16 in.	13/16 in.	1 11/16 in.
1/2 in.	7/8 in.	2 in.	1/2 in.	7/8 in.	1 11/16 in.
5/8 in.	15/16 in.	2 1/16 in.	5/8 in.	15/16 in.	1 13/16 in.
3/4 in.	1 1/16 in.	2 3/16 in.	3/4 in.	1 1/16 in.	1 7/8 in.
7/8 in.	1 1/8 in.	2 1/4 in.	7/8 in.	1 1/8 in.	2 in.
1 in.	1 1/4 in.	2 5/16 in.	1 in.	1 1/4 in.	2 1/16 in.

Table 38.—Proportions of Single-riveted Lap Joints.

912. *Q.*—What is the comparative strength of different kinds of seams?

A.—According to Forney, as given in Table 39.

913. *Q.*—What is an injector?

A.—It is an instrument by which a jet of steam imparts its velocity to water, and thus forces it into the boiler against the pressure of the steam.

914. *Q.*—What are the principles on which it works?

A.—The usual theory attributes its efficiency to the velocity with which steam escapes from a boiler at a given pressure being very much greater than that of water under the same conditions. This contends that as the water is brought in contact with a jet of steam, the latter will impart its velocity to the water, and by mixing with it the steam is condensed.

Many practical injector men disagree with this theory entirely and contend that the injector is simply a steam pump with a liquid piston. This is borne out by the fact that the steam tube or nozzle must be as much larger than the discharge tube as the steam piston of a pump is larger than the water piston. If the action were due to velocity alone, the steam tube would only need to be enough larger than the discharge tube to allow for friction of the steam.

In testing injectors, where the discharge pressure is sometimes four and five times the initial pressure, the steam tubes must be as much larger than the delivery tube as if it were a steam pump working under similar conditions.

The steam, coming in contact with the water, condenses in the mouth of the combining tube and forms a liquid piston. If there is not water enough to condense the steam at this point, the injector will not work even though this absence of water in no ways affects the velocity of the steam.

[1] This is the diameter of the rivets before being driven; the holes are usually made 1/16 in. larger.

		A	B	C	D	E	F	G	H	I
		Single-riveted lap seam	Single-riveted lap seam	Single-riveted lap seam	Double-riveted lap seam	Double-riveted lap seam	Double-riveted lap seam	Single-riveted lap seam, with welt	Single-riveted lap seam, with welt	Single-riveted lap seam, with welt
1	Materials of plates	Iron	Iron	Steel	Iron	Iron	Steel	Iron	Iron	Steel
2	Diameter of rivet holes	11/16 in	7/8 in.	7/8 in.	3/4 in.	7/8 in.	7/8 in.	11/16 in.	7/8 in.	7/8 in.
3	Straight pitch of rivets	1 7/8 in.	2 5/8 in.	2 1/4 in.	3 in.	3 5/8 in.	3 5/8 in.	1 7/8 in.	2 5/8 in.	2 5/8 in.
4	Diagonal pitch of rivets	....	....	....	2 1/4 in.	2 3/4 in.	2 3/11 in	....	....	....
		Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
5	Strength of rivets to resist shearing	74,240	131,250	131,250	132,010	180,390	180,390	148,480	262,500	262,500
6	Strength of plates through rivet holes to resist tearing	89,060	120,260	123,748	126,562	182,810	177,185	114,840	153,070	163,120
7	Strength of plates in front of rivets to resist crushing	92,812	118,125	118,125	151,875	177,183	177,183	185,624	236,250	236,250
8	Minimum strength of seam per lineal inch	9,898	11,250	13,125	14,062	14,318	16,874	15,312	14,578	18,124
9	Strength of plate per lineal inch	18,750	18,750	22,500	18,750	18,750	22,500	18,750	18,750	22,500
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
10	Strength of seam in percentage of solid plate	52.78	60	58.33	74.46	76.36	75	81.66	77.75	80.55

TABLE 39.—STRENGTH OF DIFFERENT KINDS OF RIVETED SEAMS.

915. *Q.*—How is an injector constructed?

A.—A rudimentary form is shown in Fig. 138 which will illustrate the principle.

916. *Q.*—Is it necessary for an injector to be in a vertical position to work well?

A.—No. An injector will work in any position.

917. *Q.*—How is the amount of pressure that must bear on the top of the safety valve determined?

A.—Area of the valve opening in square inches times the greatest steam pressure per square inch the boiler is intended to bear.

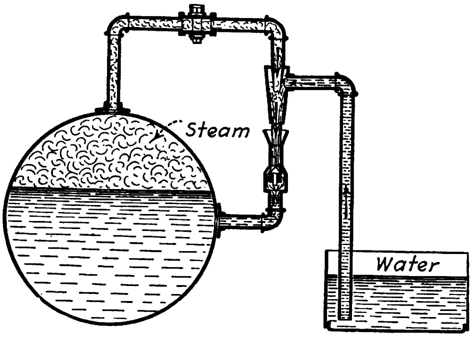


FIG. 138. SIMPLE FORM OF INJECTOR.

918. *Q.*—How are pistons made steam tight?

A.—By the use of packing rings of some kind. The more common kind being made of cast iron turned larger than the cylinder bore, and then a piece is cut out, and they are compressed to fit the cylinder, the tension keeping them in contact with the walls.

919. *Q.*—What is meant by setting a slide valve?

A.—It is the adjustment of the position of the eccentrics on the axle, and the length of the eccentric rods and valve stem, so that the valves will give the required distribution of steam.

920. *Q.*—How are ordinary slide valves set?

A.—After the wheels, axles, main connecting rods and valve gears are connected, put the rocker-arm in its middle position, and lengthen or shorten the valve-stem, so that the valve will then be in the center of the valve face. Next place the crank on the forward center and the rise of the forward motion eccentric above and that of the back motion eccentric below the axle, and fasten them temporarily by tightening the setscrews. Now throw the link down until the block comes about opposite the end of the eccentric-rod. Turn the wheels and observe whether the travel of the valve is equal to the throw of the eccentric, and also whether it travels equally on each side of the center of the valve-face. If its travel is greater than the throw of the eccentric, raise the link; if less lower it until the two are just equal, and then mark the position for the notches on the sectors or quadrants, to receive the latch of the reversing lever. If the valve does not travel equally on each side of the center of the valve-face, either lengthen or shorten the eccentric rod, as may be necessary. Repeat this for the backward motion, by raising the link until the block is opposite the end of the lower eccentric rod. After having done this, go over the whole process again to see whether it is all correct.

Next with the crank on the forward center and the link in full gear forward, loosen the setscrews in the forward eccentric, and move it around the axle so that the valve will have the required lead, then fasten it again. Now raise the link up into full back gear and set the backward eccentric the same way. Then turn the wheels so as to bring the crank on the back center, and observe whether the lead is correct for the back end of the cylinder. If it is not, lengthen or shorten the eccentric rod so as to make the lead alike at both ends, and if it is too much or too little, it can be increased or diminished by moving the eccentrics on the axle.

Great care must be taken in setting valves to be sure that the cranks are exactly on the centers or dead-points, and it is impossible to set them with sufficient accuracy from the motion of the piston or cross head alone, and therefore the centers of the crank pins should always be set so as to conform to a line drawn through the center of the cross-head pin, crank pin, and the axle.

In setting the valves, it must be borne in mind to turn the wheels forward for the forward motion and backward for the backward motion.

After the valve is set on one side of the engine, the one on the other side should be tested for each point of cut-off so as to be certain that the two valves work alike. It sometimes happens that the link-hanger or suspension link on one side must be either lengthened or shortened, so that the two links will occupy the same relation to their rocker-pins.

After the valves have been set with the pistons at the end of the stroke, the valves on each side should be tested with the pistons at half stroke, to see whether they work alike on each side with the reversing lever in different positions. It should be noticed whether the link blocks stand in the same position in the links at the beginning of the stroke of each piston. This can be known by cutting a stick to fit between the top or bottom of the block and the end of the link. Sometimes the two horizontal arms on the reversing shaft are not in the same horizontal line, and the shaft must therefore be heated and twisted so as to make the valve-motion work alike on both sides.

If the valves have been set when the engine is cold, they should be tested again when not, as the expansion of the parts may cause them to work differently.

921. *Q.*—How may the counterweights on driving wheels be calculated?

A.—A rule taken from Forney's book says to find the separate revolving weights in pounds, of crank pin, crank pin boss, coupling rods and back end of connecting rod for each wheel; also the reciprocating weight of the piston and appendages, and the front end of connecting rod; take five-eighths of the reciprocating weight and divide it equally between the coupled wheels, and add the part so allotted to the revolving weight on each wheel; the sums so obtained are the weights to be balanced at the several wheels; multiply these weights by the length of the crank in inches and divide by the distance in inches of the center of gravity of the space to be occupied by the counterweight. The result will be the counterweight, in pounds, to be placed diametrically opposite to the crank pin.

922. *Q.*—Are there any standard sizes for the inside diameters of tires?

A.—The American Railway Master Mechanics Association recommended those given in Table 40.

923. *Q.*—In what respect do tender trucks differ from the engine trucks?

A.—Principally in having journal bearings and frames outside the wheels.

924 *Q.*—Why are the bearings so placed?

A.—Because when outside they are more accessible, and the oil-boxes on the axles can be entirely closed over the ends of the axles, so that no oil can leak out or dirt get in. The only reason why engine truck bearings are placed inside, is because they would be in the way of the working parts if on the outside.

925. *Q.*—How can defects, such as cracked plates or dangerous corrosion, be discovered in a locomotive boiler?

A.—Such defects are usually indicated by leakage while the engine is in service. They are shown by a little water or steam oozing at the point where the defect exists. When the engine is cold a slight collection of incrustation or rust on the outside of the boiler will show that there has been a leak. A defect in the fire-box will often be shown by a leak at the mud-ring. When a fire-box plate is cracked it usually opens suddenly, so that the leak shows at once. Tubes are liable to leak when there is no other defect excepting that they need caulking, but when this is done the tube-plate should always be examined to see whether it is cracked.

Diameter of wheel center	Inside diameter of tire	Allowance for shrinkage	Diameter of wheel center	Inside diameter of tire	Allowance for shrinkage
20	19.979	0.021	53	52.945	0.055
21	20.978	0.022	54	53.944	0.056
22	21.977	0.023	55	54.943	0.057
23	22.976	0.024	56	55.942	0.058
24	23.975	0.025	57	56.941	0.059
25	24.974	0.026	58	57.940	0.060
26	25.973	0.027	59	58.939	0.061
27	26.972	0.028	60	59.937	0.063
28	27.971	0.029	61	60.936	0.064
29	28.970	0.030	62	61.935	0.065
30	29.969	0.031	63	62.934	0.066
31	30.968	0.032	64	63.933	0.067
32	31.967	0.033	65	64.932	0.068
33	32.966	0.034	66	65.931	0.069
34	33.965	0.035	67	66.930	0.070
35	34.964	0.036	68	67.929	0.071
36	35.962	0.037	69	68.928	0.072
37	36.961	0.038	70	69.927	0.073
38	37.960	0.039	71	70.926	0.074
39	38.959	0.040	72	71.925	0.075
40	39.958	0.041	73	72.924	0.076
41	40.957	0.043	74	73.923	0.077
42	41.956	0.044	75	74.922	0.078
43	42.955	0.045	76	75.921	0.079
44	43.954	0.046	77	76.920	0.080
45	44.953	0.047	78	77.919	0.081
46	45.952	0.048	79	78.918	0.082
47	46.951	0.049	80	79.917	0.083
48	47.950	0.050	81	80.916	0.084
49	48.949	0.051	82	81.915	0.085
50	49.948	0.052	83	82.914	0.086
51	50.947	0.053	84	83.912	0.088
52	51.946	0.054	....	....	....

Table 40.—Standard Sizes for Inside Diameters of Tires.

926. *Q.*—How can internal corrosion or grooving be discovered?

A.—Unless it has become so serious as to cause an external leak, this cannot be discovered excepting by an internal inspection of the boiler. To do this the dome-cover must be taken off and a person must go inside of the boiler and examine carefully every part that is accessible. To make an internal inspection thorough, the tubes must be taken out. When water is of a corrosive character, or contains much solid matter which is deposited inside of the boiler, such an inspection should be made frequently, but when the water is pure it is not essential to do it often.

927. *Q.*—How can defects in braces or stays or broken stay-bolts be discovered?

A.—Broken braces and stay-bolts are indicated sometimes by the bulging of the plates of the flat parts of the boiler. Broken stay-bolts may often be discovered by an expert by sounding them with a hammer, and if their ends are drilled, their fracture is shown by the leakage. An internal inspection is the only way of being sure that the braces are in good condition.

928. *Q.*—How often should the tubes be cleaned?

A.—That depends very much upon the kind of fuel used, as some coal fills up the tubes much more than other kinds do. Every time the engine is washed out the tubes should be thoroughly cleaned. If the fuel used leaves considerable deposit in the flues, it is well to brush them out as thoroughly as is possible from the furnace door.

929. *Q.*—What may happen to the exhaust-pipes?

A.—They may get loose or may require adjusting. Moving them up or down has an important influence on the draft, but experience is the best teacher with reference to their adjustment.

930. *Q.*—What may happen to the wire netting in the smoke-box or in the top of the chimney?

A.—As the wire netting on the smoke-stack often has holes worn into it by the action of the sparks, it should be frequently examined to see whether it is in good condition. As soon as holes are cut into the netting there is danger that the sparks which escape will set fire to the combustible material near the track. When the engine "throws fire" from this cause the netting should be renewed. If the engine "works water" the netting is liable to get clogged. It is also liable to be "gummed up," especially if too much oil is used in lubricating the cylinders and valves. If the netting is obstructed the engine will not make steam freely and is liable to "kick-back," that is, the fire is liable to be blown out of the furnace door and burn the men in the cab.

931. *Q.*—What should be noticed in connection with the steam and exhaust-pipes?

A.—The steam pipes should be kept tight. If there is any suspicion that the steam pipes leak, the throttle-valve should be opened slightly, so as to give the engine steam while the smoke-box door is open. The leak will then be indicated by the escaping steam. If they leak the joints must be reground. Exhaust nozzles sometimes get obstructed by a collection of oil and dirt, which should be cleaned out. It should also be noticed whether the nozzles are located so that the blast from the exhaust-pipes is discharged in the center of the chimney.

932. *Q.*—What should be noticed in connection with the throttle-valve?

A.—As a failure of the throttle-valve to work may be the cause of a most serious accident, it should be certain that it is in good working condition, that all the bolts, pins and screws, and other accessories are in good working order. It should also be known whether the throttle-valve is steam-tight. This can be learned by observing whether steam escapes from the exhaust-pipes or cylinder-cocks when the latter are open, the reverse-lever in full gear, and the throttle-valve closed. If the throttle-valve leaks, enough steam may accumulate in the cylinder, when there is no one on the engine, to start it, and in this way cause a serious accident. The throttle-lever should always be fastened with a set-screw or latch of some kind when the engine is standing still. If a throttle-valve leaks it should be reground. A disconnected throttle is now a rare occurrence, but it should be certain that the connections are all right.

933. *Q.*—What kind of attention must be given to the safety-valves?

A.—They should be adjusted so as to blow off at the required pressure, and it should be known whether the springs retain their elasticity, as they are affected by the heat of the steam, which makes it essential to renew them occasionally. One of the safety-valves should have a lever or other appliance for opening it in case it is necessary to relieve the boiler of pressure, and it should be raised occasionally to know that it is in good working order.

934. *Q.*—What is essential with reference to steam gages?

A.—Their most important function is to indicate steam pressure correctly, and as there is no part of a locomotive more liable to disorder than the steam gage, they should be frequently tested, and whenever there is any indication of irregularity in its action it should be investigated. When this is done the date should always be marked on the back of the gage or some other record should be kept of the inspection.

935. *Q.*—In inspecting the cylinders, pistons and guides, to what points should the attention be directed?

A.—It should be known whether the piston packing is properly set out—that is, whether it is tight enough to not "blow through," or leak steam from one end of the cylinder to the other, which, of course, will waste a great deal of steam. Of the two evils, it is, however, better to have piston-packing too loose than too tight, because if it is too tight it is liable to cut or scratch the cylinders so as to make it necessary to rebore them. Examination should be made to see that neither the piston-rods, pump-plungers nor guides are bent or sprung.

936. *Q.*—What must be done to keep the insides of the cylinders in good condition—that is, to prevent the packing from cutting them?

A.—They must be well lubricated when not using steam, and the packing must be properly set up, not so tight as to bind nor so loose as to blow, or allow the piston-heads or followers to rub on the bottoms of the cylinders, as the two cast-iron surfaces will then scratch each other. It is also important that the piston be central in the cylinder; if anything, have it a little higher than central. It should be set by calipering on the projection on the front side which holds the follower-plate in place.

937. *Q.*—How can it be known whether the piston-packing is too loose or "blows through?"

938. *Q.*—It can usually be noticed in the sound of the exhaust, which can be heard very distinctly on the foot-board when the furnace door is opened. If the packing is not tight, it produces a peculiar wheezing sound between and after each discharge of steam. If the packing leaks, it will also be indicated by the escape of steam from both the cylinder-cocks, if they are open, just after the crank passes the dead point. This will usually show in which of the cylinders the packing is too loose. The same thing will occur, however, if either or both of the main valves leak, so that it is often hard to determine whether the "blow" is due to a leak from the valve or from the piston. Of course it may sometimes happen that both leak, or that the piston on one side of the engine and the valve on the other leak, so that often the diagnosis of the disease, as the doctors say, is extremely difficult. Careful observation and experience will, however, aid in detecting such defects much more than any directions which can be given here.

939. *Q.*—What is meant by piston-packing being "follower-bound?"

A.—It means that when the follower-plate is bolted up hard against the piston-head that it clamps or binds the packing rings between the plate and the piston-head so that the rings cannot move.

940. *Q.*—How can it be known whether the packing is follower-bound?

A.—When the packing can move as it should between the piston-head and follower-plate its movement is usually shown by marks on the follower-plate when it is taken off. If such marks are not apparent, and there is reason to think that the packing is too tight, the piston should be taken out, the packing put in place, and the follower-plate bolted on. The packing should then be loose enough, so that it can be moved by tapping it with a piece of wood. If it is too tight a piece of paper should be inserted between the follower-plate and piston-head where they are in contact with each other.

941. *Q.*—If the stuffing-box of the piston-rod leaks, what should be done?

A.—If it is packed with fibrous packing and it is in good condition, it can usually be made tight by simply screwing up the nuts on the gland. In doing this, they should not be screwed up more than is necessary to make the packing steam-tight. Any greater pressure only increases the friction on the piston-rod unnecessarily. The bolts should be screwed up equally, otherwise the gland will be "canted"—that is, inclined so as to bind or bear unequally, and very hard against the piston-rod, and thus be liable to cut or scratch it. After packing has been in the stuffing-box a long time, it becomes very hard and compact, and sometimes partly charred. It must then either be removed and new packing should be put in, or, if it is in tolerably good condition, it can often be made to work well by simply reversing it—that is, by putting that which was at the bottom of the stuffing-box on top and *vice versa.* Before packing is put into a stuffing-box, the former should always be thoroughly oiled.

942. *Q.*—What kind of attention should be given to piston-rods?

A.—They should be oiled occasionally and kept keyed up tight in the cross-head and piston.

943. *Q.*—What must be done to keep the cross-head slides and the guide-bars in good condition?

A.—They must be in line or parallel with the center line of the cylinder and they must be kept well lubricated. There are no parts of a locomotive which require more careful attention in order to keep them lubricated, and thus prevent them from heating and cutting than the bearings on the crank-pins and the slides of the cross-head. A little lost motion in the guides is not a serious evil unless it becomes excessive.

944. *Q.*—When the slides of the cross-heads are considerably worn, how is the lost motion taken up?

A.—When there are gibs on the cross-head, the lost motion can be taken up by putting liners or shims between them and the cross-head, so that they will fill up the space between the guide-bars. When there are no gibs, the guide-bars must be taken down, and the blocks between them at each end should be reduced in thickness so as to bring the bars nearer together. In doing this, great care must be taken that the guides are accurately in line with the center line or axis of the cylinder when they are put up again. This work should never be intrusted to any excepting skilled workmen, from whom those who are inexperienced should seek instruction.

945. *Q.*—What kind of attention should be given to the crank-pins and connecting-rods?

A.—They are all liable to break, and they should be examined often to see whether there are any crack or flaws in them, or whether any of them are bent or sprung. Whenever the rods are taken down the straps should be looked over carefully, especially in the inside corners, to see whether any flaws exist. Main-rods are less liable to break than coupling-rods. Attention should be given to the brass bearings of the connecting-rods to see that they are not so loose as to thump, nor keyed so tight on the crank as to be liable to heat. The latter can be easily known by moving the stub-end lengthwise of the journal. They should never be so tight that they cannot be thus moved with the hand. Especial attention should be given to seeing that all the bolts and nuts on the connecting-rods are tight.

946. *Q.*—When the brass bearings of the connecting-rods become too loose on their journals, what should be done?

A.—They must be taken down, and the two surfaces in contact must be filed away so as to bring them closer together. In doing this they must be filed square with the other surfaces, otherwise they will not bear equally on the journals when they are keyed up. Before attaching them permanently to the rods, they should be keyed on the pin in the strap alone, so that it can be known by trial whether they move freely and yet are tight enough to prevent thumping.

947. *Q.*—How should the valve-gear be taken care of?

A.—The principal defects of valve gear are due to want of proper lubrication. The oil-holes should all be kept clear, otherwise it will be impossible to keep the journals well oiled. The eccentric straps and the link blocks are very liable to be imperfectly oiled, and when the former become dry and cut, they throw a great strain on the eccentric-rods, which is liable to break them. When this occurs, the strap and the portion of the rod which is attached to it revolve with the eccentric, and frequently a hole is thus knocked in the front of the fire-box, which disables the engine. The valve gear is, with the exception, perhaps, of the air pumps and injector, the most delicate part of the locomotive, and more liable to get out of order than any other, and should therefore be examined carefully, and if there are any indications that the eccentric straps or any of the pins are cutting, they should be taken apart, examined, and thoroughly oiled.

It is usual now to key eccentrics fast to the axle so that it is impossible for them to slip. When they were fastened with set screws alone they had to be examined occasionally to see whether they had moved from their original position.

All the bolts, nuts, and keys should be carefully examined to see that they are properly fastened. The bolts and nuts in the eccentric straps are especially liable to become loose, and as they are between the wheels, and therefore not easy of access, are often neglected.

948. *Q.*—How can it be known whether the main valves of a locomotive are tight?

A.—As already indicated, the symptoms which manifest themselves when a valve leaks are very similar to those which appear when the piston packing leaks. If the valve is moved to its middle position and steam is admitted into the steam-chest, it then escapes from both cylinder-cocks, it is apparent that the valve is not tight. But the valve faces of locomotives usually wear concave, because the valves are worked most about half-stroke, so that they will often be tight when in the center of the face, but will leak at the ends of the full stroke. This will become apparent by the peculiar wheezing sound, already referred to, when the engine is at work. As has been explained, it is often very difficult to determine whether this sound is due to a leak at the pistons or the valves. If the packing of the valve-stem leaks, it can be remedied in the manner described for making that of the piston-rod tight.

949. *Q*.—What precaution must be taken with reference to springs, hangers, and equalizers?

A.—Like all other parts, they should be examined often to see that they are in good condition, and it should be observed whether the springs come in contact with the boiler—if they do they may rub against it and wear a hole in it.

950. *Q*.—Into what two classes are injectors divided?

A.—Into lifting and non-lifting.

951. *Q*.—In the examination, care of, and repairs to injectors, what precaution should be observed?

A.—(1) The pipe connections should be kept perfectly tight to prevent air leaks. This is vital in the suction pipes.

(2) The steam-valves should be kept tight to prevent escaping steam from heating the suction-pipe, which interferes with the formation of a vacuum and prevents the instrument from lifting the water.

(3) The packing of the different spindles and valve-stems should be kept in good condition, so that they will be steam or air-tight.

(4) The nozzles of the injector must be taken out and thoroughly cleaned more or less often—according to the character of the water used—so as to keep them as far as possible free from incrustation. Mineral oil drawn with the water, when the injector is at work, will have an excellent effect in keeping it free from scale. Some injectors are arranged to receive an oil-cup for this purpose.

(5) The boiler check-valves must be kept tight and free from dirt and incrustation, to prevent the back-flow of hot water and the sticking of the valves.

952. *Q*.—If a lifting injector is tested and does not lift the water properly, to what causes may it be due?

A.—(1) To a leak in the steam-valve, and the consequent heating of the suction-pipe to such a degree as to prevent the formation of sufficient vacuum in that pipe. This defect can be remedied only by grinding the steam-valves, so as to make them tight. Such a leak will be indicated by an escape of steam from the overflow when the steam-valves are closed.

(2) To a leak in the suction-pipe or its connection, in which case the air drawn in by applying the lifting jet will prevent the formation of the vacuum. Such a leak can be detected by closing the heater-cock and opening the main steam-valve only—if there is a separate lifting jet—or, with a single lever instrument, by opening both steam-valves at once. The steam blowing back to the tank will then escape through the leak, if there is one. The trouble will usually be remedied by tightening up the suction-pipe connections.

(3) To a leak in the boiler check-valves and the consequent heating of the suction-pipe by the hot water from the boiler flowing back through the injector. Grinding the check-valve will remedy this.

953. *Q.*—If the injector lifts the water, but does not take it up and throw it out through the overflow, or the stream flowing into the boiler breaks, to what causes may it be due?

A.—(1) To a slight leak in the suction-pipe, not sufficient to prevent a short lift, but enough so that the air drawn in disturbs the current in the nozzles. Such a leak can be detected and remedied as explained in answer to the previous question .

(2) To obstructions in the suction-pipe, floating matter, bits of wood, hemp, leaves, obstructions in the strainer, or not sufficiently large strainer to admit the proper supply of water. If the strainer is obstructed it must be taken out and cleaned. The strainers consisting of a perforated cone inside of the suction-pipe, are a frequent cause of trouble in the working of injectors. They are usually not large enough, and difficult of access for cleaning. The suction-pipe itself can be cleaned by blowing steam through it with the heater-cock closed.

(3) To boiler check-valves sticking fast, on account of corrosive incrustation, or dirt in the valve-chamber, which prevents the free action of the valves. The remedy is to open the valve-chamber, and thoroughly clean the valve, its seat, and guides.

(4) To leaky heater-cock check, which will be indicated by a sputtering sound, which is again caused by the air taken in through the overflow. Grinding the check will remedy it.

954. *Q.*—What should be observed in lubricating a locomotive or any other machinery?

A.—The most important thing to observe is that the oil reaches the surface to be lubricated. It is of much greater importance that the lubricant should reach the right place than that a large quantity should be used. A few drops carefully introduced on a journal will do much more good than a large quantity poured on the part carelessly. For this reason all oil-cups and oil-holes should be kept clean so as to form a free passage for the oil. It should also be remembered that no automatic oil-cup will work satisfactorily a great while unless it receives the attention which all of them require.

CHAPTER XXIV

MACHINE-SHOP COMPUTATIONS

955. *Q.*—How much mathematics are necessary in the machine shop?

A.—Many men get along with only enough to figure their pay at the end of the week; but the man who is interested in his work will constantly find problems which can only be answered by knowing considerably more than this. Probably proportion, or the rule of three, is the most useful of all in shop work, but it will often be found extremely convenient if one can handle square and cube root, or has access to a convenient and fairly complete table from which the answers can be taken.

956. *Q.*—Why is proportion so much used?

A.—Because so many features of shop work bear proportionate relations to each other. This is true in all gearing and belting problems, screw cutting, indexing and similar kinds of work.

957. *Q.*—How is this used in thread cutting?

A.—If the lathe has a lead screw of four threads per inch, and it is desired to cut a screw having twelve threads per inch, it is at once seen that the threads to be cut are three times as fine, or that there are three threads on the screw to be cut for every thread on the lead screw. This means the piece of work on which the thread is being cut must revolve three times while the lead screw is revolving once, in order that there may be three threads cut on the work in every quarter-inch of length. This proportion shows exactly what gearings must be used, as they must be in the proportion of three to one, or one to three, according to the way we prefer to state it. This means that there can be selected any two gears, one of which has three times as many teeth as the other, such as 24 and 72, 30 and 90, 32 and 96, or any other pair which we happen to have on the lathe.

958. *Q.*—Where are these gears placed?

A.—This is the next step and, as seen in this case, the lead screw must revolve slower than the work, we put the large gear on the lead screw, and the small gear on the stud. If these gears are reversed and run the lead screw three times as fast as the work, we should cut a thread of 1 1/3 to the inch, providing the lathe gearing would stand the strain.

959. *Q.*—Can this be stated as a rule?

A.—Yes, and in a number of different ways. For example, divide the thread to be cut by the lead screw, which gives the proportion or ratio between the two. Then select any two gears having this ratio as the proper gears to be used. When the thread to be cut is finer than the thread of the lead screw, put the large gear of the pair on the lead screw, and when the thread to be cut is of a coarser pitch than the lead screw, the small gear must be put on the lead screw.

960. *Q.*—Is there an easier rule?

A.—An easier rule is, multiply both the lead of the thread to be cut and the lead screw by any number which will give two gears you have in the change gear set. It does not matter what number you use, whether a whole number or a fraction, providing you use the same number in multiplying both cases. Using the same threads as in the previous example, that is, having a four-pitch lead screw to cut twelve threads to the inch, multiply both four and twelve by any number, such as 6, 6 1/2, 7, 8, or anything else which will give the gears available. Multiplying by 6 gives 24 and 72, by 6 1/2 gives 26 and 78, and by 7, 28 and 84. Any of these pairs will give the same result. Instead of including the location of each gear in the rule, it is always easier to use the method suggested in the previous paragraph, of determining whether the lead screw must run slower or faster than the work, and placing the gears accordingly. This often prevents mistakes which are frequently made where men depend entirely on a rule without knowing exactly why it is used.

961. *Q.*—What is compound gearing?

A.—Compound gearing means that a pair of gears having a definite relation to each other are interposed in the train between the stud and the lead screw, so as to either increase or decrease the relative motion of the two.

962. *Q.*—When are these used?

A.—Compound gearing is only used where the set of change gears does not include the gears necessary to cut the desired thread. Suppose, for example, it is necessary to cut a 32 thread with a four-pitch lead screw. The smallest gear usually supplied has 24 teeth, which makes it necessary to use six as the smallest multiplier in this case. Six times four equals 24; while six times ~~six~~ 32 ✓ equals 192, and no set of change gears contains this number of teeth; in fact, 96 is usually about the largest gear provided.

If, however, there is used a two to one reduction on the compound, such as a 24- and a 48-tooth gear fastened together, the large gear being driven from the set, and the small gear of the compound pair driving the lead screw, there can be used a gear with one-half 192 teeth, or 96 teeth; or, there can be used a three to one reduction for the compound, such as a 24- and a 72-tooth gear, the 72-tooth gear being driven from the stud and the 24 acting as the driver for the lead screw.

963. *Q.*—How can it be known what thread will be cut?

A.—In order to make sure exactly what thread will be cut, multiply the lead screw and its gear, or four times 192 equals 768, and divide by the gear on the stud, or 24, which gives 32, or the thread which will be cut. In the case of the compound gear, used because there are not available gears as large as 192 teeth in the set, the calculations are practically the same, bearing in mind that every ***driven*** gear belongs to the lead screw, and every ***driving*** gear belongs to the stud. Going over the calculation again with the two to one compound, remembering that the gear on the stud drives the large gear of the compound pair, and that the small gear of the compound also drives the large gear on the lead screw, we have 96×48×4, divided by 24×24, which again gives 32 as the threads that will be cut. The calculation can be carried through in exactly the same way, whether the compound is two to one, or any other ratio that may be either necessary or convenient.

964. *Q.*—How about cutting fractional threads.

A.—Fractional threads are calculated in exactly the same way, but owing to the fact that they are fractions, it is easier to make mistakes, and on that account should be watched more carefully. Fractional threads in this connection are usually taken to mean threads coarser than one per inch, such as 1 1/2 threads (or turns, as it is sometimes stated) in 2 in. This should be reduced to the amount of turns per inch, which in this case is clearly seen to be 3/4 of a turn for every inch of travel. This means that a lead screw having four threads per inch must make four revolutions and move the carriage 1 in. while the work is turning 3/4 of a revolution. But as we are accustomed to thinking of one complete thread, we reduce this to inches by remembering that 2 in. equal 6/3, and that as there are 1 1/2 turns every 2 in., there must be one complete turn at 4/3, or 1 1/3 in.

965. *Q.*—Is there another method?

A.—This same result can be obtained by simply reversing the 3/4 of a thread per inch, which shows that 4/3 revolutions, or 1 1/3 revolutions, are required for a complete thread. This shows us that the lead screw must be turned fast enough to move the carriage 1 1/3 in. for each turn of the work or lathe spindle. This shows that the four-pitch lead screw must be turned four times 1 1/3, or 5 1/3 times as fast as the spindle. Multiplying 24 by 5 1/3 would give 128 teeth as the proper gear to use, and as the lead screw must turn faster than the work, the large gear must go on the stud. We can, however, use a two to one compound, so that a 64-tooth gear will answer on the stud, but it must be used as a multiplying instead of a reducing compound, as in the other case.

966. *Q.*—Cannot distance between threads be considered?

A.—Yes. Another and perhaps easier way to handle this proposition is to consider the distance between threads on both the lead screw and the work to be cut. If, for example, we have to make a thread of 1 1/4-in. pitch, or 1 1/4 in. from the center of one thread to the center of the next, we can proceed as follows:

As the threads of the lead screw are 1/4 in. apart, it is very evident that the 1 1/4-in. pitch is five times as fast, so that it becomes very clear that we must revolve the lead screw five times as fast as the work, which would mean a 24 gear on the lead screw and 120 on the stud, or a 60 on the stud with a tooth compound used as a multiplier, as in the previous case.

967. *Q.*—What is meant by metric threads?

A.—The pitch of metric threads is given in millimeters, which gives the distance from one thread to the next. When metric threads are cut with a lead screw in inches, the number of threads per centimeter are taken and used in same way as threads per inch.

968. *Q.*—Can metric threads be cut on lathes provided with regular lead screws?

A.—Metric threads can be cut with sufficient accuracy for almost all purposes on a lathe provided with an English lead screw, by using what are called translating gears. These translating gears are simply a reducing compound having gears of 50 and 127 teeth instead of the reductions usually employed. With the 50-tooth gear as the driver of the pair, the 127-tooth being driven from the head, the carriage travel will be reduced in proportion to 2.54 to 1, which gives the proper carriage movement, as there are 2.54 centimeters to the inch. And these translated gears reduce the carriage movement in the same proportion as a centimeter is less than an inch.

969. *Q.*—Suppose there is to be cut a metric screw having a pitch of 2 mm.?

A.—In cutting metric screws in this way it is necessary to reduce the pitch to threads per centimeter and to remember that 1 cm. equals 10 mm. If the screw to be cut has a pitch of 2 mm. it is very evident that there will be five threads per centimeter, and we proceed just as though we were gearing a lathe to cut five threads per inch. Still assuming that the lead screw has four threads per inch and using 6 as a multiplier, the rule would give $6\times4=24$, and $6\times5=30$, and as the thread to be cut is finer and as five threads are finer than four, the large gear goes on the lead screw, as before.

970. *Q.*—How is the amount to set over the tail stock in turning tapers calculated?

A.—This depends on how the taper to be turned is designated. If it is given in degrees of an angle it is best to translate this into inches per foot by some table prepared for this purpose, such as can be found in the "American Machinist Handbook." If, as in most cases, the amount of taper is given in inches per foot or fractions of an inch per inch, first find the proportion or relation between this and the length of the piece being turned. Taking the case of the regular pipe thread taper, which is 1 in. in 16 in., or 3/4 in. to the foot, and we have an easy basis for figuring, from which we can easily see how any taper can be figured.

If the piece is 16 in. long it is very evident that the diameter at one end must be 1 in. smaller than at the other, and as we usually turn tapers with the small end toward the tail stock, we assume this to be the case. With the bar 16 in. long, it can be clearly seen that the tail stock should be moved *toward* the cutting tool 1/2 in., or one-half the amount of the taper, as the tool cuts an equal amount each side of the center. If the piece is only 12 in. long, the total taper will be only 3/4 in., which means that the tail stock will only need to be set 3/8 in. toward the cutting tool. All taper work assumes that the point of the cutting tool is at the same height as the lathe spindle, as any deviation either above or below affects the taper, which will be cut. It is also very misleading, as the taper changes slightly with each cut taken under these conditions. To see exactly what this means, assume an exaggerated case with the tool point 1/2 in. below the center of the spindle, and it will readily be seen that when the small end of the bar is turned to a diameter of 1 in. it will not cut at all at that point, but will increase its cut as the diameter of the bar increases.

971. *Q.*—Can a rule be given for this?

A.—The easiest rule to remember is, to first calculate the total taper of the entire bar, whether the taper extends the whole length or not. In other words, no matter how short the taper portion may be, find what the total taper or the total difference in diameter between the small end would be if the taper continued the whole length of the bar. Set the tail stock toward the cutting tool one-half of this amount, and you have the correct setting for all taper work. If it should happen that it is necessary to have the large end of the taper at the end of the bar, then the tail center must be set *away* from the cutting tool.

972. *Q.*—How is cutting speed in a lathe figured?

A.—As cutting speed is always given in feet per minute, it is first necessary to find the number of feet or parts of a foot in the circumference of the piece of work being turned or bored. To do this it is only necessary to multiply the diameter by 3.1416, or if it is any easier by 3 1/7 which is practically the same. If the diameter is taken in feet the answer will also be in feet. But if the work is measured in inches, as is almost always the case in lathe work, it will be necessary to divide the answer by 12 to change it into feet. Having the number of feet, or parts of a foot, represented by one turn of the work, it is only necessary to multiply it by the number of revolutions per minute to have the cutting speed in feet per minute. If the diameter happens to be 1 ft., then the circumference, or distance around it, is 3 1/7 ft. and if the lathe is making 10 revolutions per minute, we find by multiplying these together that the speed of the outside is 31.7 per minute.

973. *Q.*—How does this work on small diameters?

A.—In average lathe work, the diameter is very much less than a foot, and, assuming it 2 1/2 in. we multiply this by 3.1416 and find that it is 7.85398 in. around. For work of this kind we can safely drop all except one decimal place, and dividing 7.8 by 12 we see that the circumference of the piece is 0.65 ft. If we find that the lathe is running 50 turns a minute, we see that 50 times 0.65 is 32.5, which is the cutting speed in feet per minute.

974. *Q.*—How is the proper lathe speed to give any desired cutting speed found?

A.—Take the same case as before and suppose we want a cutting speed of 70 ft. per minute. Dividing the desired speed by the circumference of the piece and we get 70 divided by 0.65 = 107+ revolutions per minute. As one revolution gives only 0.65 ft., it will evidently require much more than 70 revolutions per minute to give the desired cutting speed. It is readily seen that this is correct.

975. *Q.*—How is the time required for turning a piece of work estimated?

A.—This is easy when we know the revolutions of the work and the feed per minute of the tool. If we only know the cutting speed it will be necessary to calculate the circumference of the piece in order to find the number of revolutions per minute; but in most cases this will be given so that it becomes a very easy calculation. With a 1/4-in. feed, which means that the tool advances 1/4 in. for every revolution of the work, it is very evident that it will turn 1 in. for every four turns of the work. If the work is fairly large, as would probably be the case in order to stand a feed of 1/4 in. per revolution, we may assume that the lathe is making 20 revolutions per minute. Then if the tool advances 1 in. for every four turns of the work it will advance 1 in. in one-fifth of a minute, or 5 in. per minute.

976. *Q.*—What would the rule be for this?

A.—Divide the number of revolutions per minute by the feed per revolution. Calling the work speed 23 revolutions per minute, and the feed 1/16 in. per revolution, we divide the revolutions per minute by the feed and get 23/16, or 1 7/16 in. per minute. This will be perfectly plain if we consider that there are as many sixteenths of an inch feed as there are revolutions per minute of the work. Working along this line all calculations of this kind become easy.

977. *Q.*—How is the cutting speed of a planer calculated?

A.—There is more or less confusion in regard to this on account of the time lost by the return stroke. If the planer carries the work against the tool at the rate of 30 ft. per minute, this is the cutting speed so far as the life of the tool is concerned. If, however, the planer table returns at the same speed, it consumes half of the time in running back, so that in figuring the production of work from the planer we can only call it 15 ft., this being the average of the round trip. This becomes more complicated as the planer is speeded up. If we increase the return speed to 90 ft., which is common, it then requires only one-third as long for the table to return as it does to cut, so that the total time may be represented by 1 1/3, or 4/3. This means that 30 ft., instead of twice the actual cutting speed, as in the other case, is only 4/3, and dividing 30 by 4, and multiplying the dividend by 3 gives us 22 1/2 ft. as the actual cutting speed under these conditions so far as the time consumed is concerned.

978. *Q.*—How about the cutting speed of shapers?

A.—This presents an entirely different proposition, for here we count by revolutions per minute and not by cutting speed. If the shaper is running 30 revolutions per minute and making a cut 1 ft. long at each stroke, it is cutting 30 ft. of metal per minute regardless of the return feed, so far as the actual work done per hour is concerned. In reality, however, it is cutting faster than this, depending on the return speed ratio.

If the return is the same as the cutting stroke then the actual cutting only requires half the time, so that the real cutting speed is twice this, or 60 ft. per minute. If it returns at twice the cutting speed, then the return stroke takes one-third and the cutting stroke two-thirds of the time. As the tool travels 60 ft. per minute, counting both forward and backward strokes, and it makes 30 backward strokes, or 30 ft. in one-third of a minute, it travels 90 ft. per minute on the return stroke. And as it makes 30 forward strokes, or 30 ft. in two-thirds of a minute, then the actual cutting is 1 1/2 times 30, or 45 ft. one-half as fast as the return stroke.

CHAPTER XXV

SHOP RECIPES

979. *Q.*—What is a good solution to use for marking on blue prints?

A.—The following has been recommended by various correspondents:

Add to a small bottle of water enough washing soda to make a clear white line, then add enough gum arabic to prevent it spreading and making ragged lines.

To make red lines, dip the pen in red ink and then add a little of the soda solution to this by means of a quill.

A pen with a sharp point must be used, as a blunt pointed one will not work well.

980. *Q.*—How can ordinary paper be sensitized for blue printing?

A.—As a rule, good blue print paper can be bought so cheaply and easily that it doesn't pay to bother with making it. However, the following will give very satisfactory results, when carefully done.

Dissolve 3 3/4 oz. ammonium citrate of iron in 18 oz. of water in a bottle. Then dissolve 2 5/8 oz. of red prussiate of potash in the same amount of water, in another bottle. When ready to prepare the paper, have the sheets piled close at hand in a photograph dark room, using only a ruby light. Now mix well equal parts of the solution from the two bottles, and apply to the paper with a sponge. Put on in long parallel sweeps as evenly as possible, and one side of the paper only. Then hang up to dry, keeping it dark till used.

Throw away any of the mixed solution that is left as it spoils quickly.

981. *Q.*—What can be done with an over-exposed blue print?

A.—Wash as usual, then sponge with a weak solution of chloride of iron, and unless very badly burned, the result will be good.

982. *Q.*—What is the process to intensify or "tone" a blue print?

A.—Immerse the print, after washing as usual, for about half a minute in a solution made by dissolving a teaspoonful of potassic bromide crystals in a half gallon of water. Then rinse thoroughly and hang up to dry.

983. *Q.*—What is the best way to preserve blue prints used in the shop to work from. Our prints are 12×14 in.?

A.—A good way is to paste on stiff pasteboard, and then coat the surface with thin white shellac. Dirt or grease may then be easily washed off at any time with soap and water, without injury to the print, as shellac is insoluble in water.

984. *Q.*—How are reference tables that are frequently handled preserved?

A.—Dip in lacquer and hang up to dry. This not only makes the paper dirt proof, but toughens it also.

985. *Q.*—What can be used to clean dirty tracings?

A.—Sponge with gasolene.

986. *Q.*—What kind of ink may be used to write on celluloid triangles or other instruments?

A.—Use anhydrous acetic acid. The writing will appear dull on the glossy surface. If colored writing is wanted, color the acid.

987. *Q.*—What kind of acid is used for etching on metal?

A.—The following are recommended by various correspondents for different metals:

For soft steel use 4 parts water and 1 part nitric acid.

For hard steel: Acetic acid, 1 part to 2 of nitric, or water 88 parts, chlorate of potash 2 parts and hydrochloric acid 10 parts.

For bronze: Nitric acid, 100 parts and hydrochloric 5 parts.

988. *Q.*—What mixture is used for etching on steel by the use of a rubber stamp?

A.—The steel is polished and then coated with guaiacum varnish. The rubber stamp containing the design or lettering desired is then coated on the face with a thin solution of caustic potash and pressed onto the varnished surface. Wherever the potash coated stamp touches the varnish, it is eaten away down to the steel, and the steel is then free to be etched with dilute nitric acid.

989. *Q.*—What is a good mixture to apply to the surface to be etched for marking with a scriber or engraving tool?

A.—Four mixtures are given herewith:

Yellow wax	50	30	110	40
Syrian asphalt	20	20	25	40
Rosin				20
Amber			20	
Mastic	25	25	25	
Tallow				2
Burgundy pitch				10

990. *Q.*—How is etching "in relief" done when it is desired to make the lettering stand out and not be cut into the metal?

A.—A good way is to use a rubber stamp. Coat the face with black asphaltum varnish and apply to the polished surface of the steel to be etched. Then apply the etching solution. This will give the desired relief effect.

991. *Q.*—What mixture can be used to stick broken pieces of iron together, where the strain is not very great?

A.—Mix equal parts of sulphur and white lead with about 1/6 part of borax. When ready to use, wet with strong sulphuric acid, spread on the break or joint and clamp together for several days.

992. *Q.*—What can be used to fill holes in castings?

A.—Use 80 parts of sifted cast-iron turnings or filings, 2 parts powdered sal ammoniac, and 1 part sulphur. Mix into a paste with water and use at once.

Another consists of 1 part red lead and 1 1/2 parts litharge mixed with glycerine; or sometimes litharge and glycerine are used.

993. *Q.*—What is usually used to make pipe joints water tight?

A.—Red lead and oil, white lead or graphite, or various mixtures of these.

994. *Q.*—What kind of a cement or mixture can be used to make a joint steam tight?

A.—White lead ground in oil mixed with a quarter as much manganese oxide and one-tenth as much litharge. Knead this together thoroughly and press into place, first oiling the surfaces with linseed oil.

995. *Q.*—What mixture will make high-pressure joints steam tight?

A.—Litharge, 10 lb.; plaster of Paris, 4 lb.; yellow ochre, 1/2 lb.; red lead, 2 lb.; cut hemp fiber, 1/2 oz. Mix to consistency of putty with boiled linseed oil. The hemp should be in about 1/2-in. lengths.

996. *Q.*—How can cloth be cemented to iron?

A.—If the piece of iron can be heated, heat it till just too hot to touch, then coat with orange shellac and press on the cloth.

997. *Q.*—What besides glue or shellac can be used to stick emery cloth to a grinder disk?

A.—Silicate of soda may be used. This is also known as liquid glass, and the hotter the disk gets the better it sticks.

998. *Q.*—What cement is used to stick rubber to iron?

A.—If a pulley or similar piece, swab the surface with hydrochloric acid and let stand over night. Scrape the rubber thoroughly to remove any "bloom," then coat both the iron and the rubber with orange shellac and let dry; then coat the iron again with a good coat of shellac and at once apply the rubber under pressure and let stand for at least five hours.

999. *Q.*—How are the scarfed ends of leather belts cemented together?

A.—Use any of the standard belt glues, or take 1 lb. of good white glue and 1 oz. of powdered white lead (not whiting); mix to the consistency of ordinary glue with water as usual. Just before using, thin with alcohol, apply hot, and clamp the ends together till well set.

Another mixture is: Gutta percha, 1 lb.; crude rubber, 4 oz.; linseed oil, 2 oz.; pitch, 2 oz. and shellac 1 oz. Melt and apply hot.

1000. *Q.*—How can handles of tools, be prevented from coming off?

A.—Fill the hole in the handle with heavy orange shellac. Heat the tang of the tool and press into place.

1001. *Q.*—What cement will stick glass and brass together?

A.—Caustic soda, 1 part; rosin, 3 parts; plaster of Paris, 3 parts, water, 5 parts. Boil together, let cool and apply. It will harden in about 20 minutes.

1002. *Q.*—What glue or cement will resist water?

A.—Shellac is probably the simplest and best for all round use.

1003. *Q.*—What are the ingredients of fire cement?

A.—100 parts wet fire-clay, 3 parts white sand and 1/2 part powdered asbestos.

Mix and add enough water to make a smooth mortar.

1004. *Q.*—Give a formula for a fire clay that will stand a high temperature.

A.—Use 45 parts crushed fire brick; 50 parts fire clay and 5 parts clean, sharp sand. Make heavy paste with water, tamp into place and burn dry.

1005. *Q.*—What mixture is used around the tuyéres of forges?

A.—A very satisfactory mixture consists of 20 parts fire clay; 20 parts cast-iron turnings; 1 part common salt and 1/2 part sal ammoniac. Mix dry and then wet down to thick paste. This dries hard and glazes well.

1006. *Q.*—What will remove paint, tar or lacquer from machines and tools?

A.—Mix 4 oz. benzol, 3 oz. fusel oil and 1 oz. alcohol. Apply, and in ten minutes rub off with waste.

1007. *Q.*—How can small screws be kept from rusting into place when exposed to dampness?

A.—Use a mixture of oil and fine graphite, and coat the screw threads and inside of the hole with it.

1008. *Q.*—How can machinery be kept bright and free from rust?

A.—Take 1 lb. of lard. Melt it and dissolve in it 1 oz. of camphor. Remove the scum and stir in enough powdered graphite to give it the color of iron. Clean the machinery and smear the above compound on the bright parts. After 24 hours more wipe the surfaces clean with a soft cloth. Machinery thus treated will, under ordinary conditions, keep clean for months.

1009. *Q.*—How may rust be removed from small parts, such as screws and the like, when a tumbling barrel is not available?

A.—Dip them, if not too pitted, in a dilute solution of sulphuric acid, made just strong enough to cut the rust off clean. Then rinse off in soda water and dry in sawdust.

1010. *Q.*—What is a good cleaning solution for brass?

A.—Nitric acid, 1 1/2 oz.; saltpeter, 1 dram; and rain-water, 2 oz. Let the mixture stand for a few hours, then dip the articles in it or swab them, washing off well afterward.

1011. *Q.*—What is putz pomade?

A.—It is a polish made in the following manner:

Oxalic acid, 1 part; jeweler's rouge, 15 parts; rotten stone, 20 parts; palm oil, 60 parts; petrolatum, 5 parts. Pulverize the oxalic acid and the rotten stone and mix thoroughly with the rouge. Sift to remove all grit, then make a paste by stirring in the oil and petrolatum. A little nitro-benzol may be added to scent the paste.

1012. *Q.*—When trouble in making copper-solution stick to the steel is experienced what is the remedy? What copper solution will stick to oily steel?

A.—The following mixture will solve the difficulty:

One-half ounce sulphate of copper (blue vitriol) and 4 oz. water. Dissolve and then add, drop by drop, 1 teaspoonful of sulphuric acid.

Apply to the steel with a small swab.

1013. *Q.*—What will remove the scale from drop forgings?

A.—Immerse in a solution of 1 part sulphuric acid to 24 parts hot water.

1014. *Q.*—What is a good dressing for leather belting?

A.—The belting manufacturers use neat's-foot oil or castor oil, but be careful not to use too much, as an excess of either will make the belt very limp.

1015. *Q.*—What is a good soap-water mixture to use on machine steel?

A.—One barrel of water, 2 buckets of lard oil and one pint can of caustic potash. Let the pump churn this till an emulsion is formed. Used lard oil does as well as fresh.

1016. *Q.*—What will prevent plaster of Paris used for pattern work from setting too quickly?

A.—Before mixing, add 1 oz. of citric acid to water sufficient for 100 lb. of plaster of Paris. This will delay the setting for one or two hours.

1017. *Q.*—Is there anything besides an acid that will delay the setting of plaster of Paris?

A.—Yes. A little glue water will retard setting.

1018.. *Q*—What will prevent plaster-of-Paris patterns expanding after being formed?

A.—Expansion is usually caused by mixing with cold water. Mixed with hot water, the effect is minimized.

1019. *Q*.—What is a good whitewash for shops and out-buildings?

A.—Mix one part fine Portland cement with enough lime to form eight gallons of whitewash. The cement makes it stick and is unaffected by the weather.

1020. *Q*.—What will take the grime off of a mechanic's hands quickly, without injury?

A.—Pound up a cake of sapolio and mix with a cupful of hot lard, and use the same as soft soap.

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